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SELECTION OF PUMPING STATION EQUIPMENT[1]

BY A. P. PIGMAN[2]

There is a somewhat natural tendency among many engineers to advocate, for practically all pump station installations, a single type of pumping equipment. Some, for example, believe that all plants should be electrified; others that the Diesel engine usually makes the best installation and many say that the steam plant, with few exceptions, is the only reliable and efficient type of pump station. These last are in turn divided between the advocates of turbine driven centrifugal pumps and reciprocating equipment.

I say that this is a somewhat natural tendency because a fundamental process of the scientific or engineering mind is the effort to simplify, to reduce the apparent variety and complexity of nature into simple, understandable conceptions and formulae with which man can work. Imagine how much the work of the engineer and of the executive in the water works field would be reduced, to say nothing of the national economy effected in the manufacture of water works equipment, if it could be shown, in a manner convincing to all concerned, that there was just one type of pumping station and pumping equipment best suited to all situations.

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In the building of new pump stations or the installation of new pumping equipment there is, however, such a variety of situations to be met that such extreme simplification of the task is not yet possible. It shall be the purpose of this paper to paint, as well as it can, some picture of the variety of these circumstances and to demonstrate that these many different needs call for a variety of solutions.

When an engineer is given the problem of selecting equipment for pumping water, this problem may consist of building an entirely new station or of merely putting in additional equipment in an old station. The pumps may be required to pump tremendous quantities of water or very small quantities. They may have to pump this water against 10 or 15 feet or against 500 to 1000. The water may be sandy river water, filled with trash; it may be clear filtered water taken from a basin, or well water taken from the ground; or it may be all three of these. The rate of pumpage may be practically constant or it may vary in the ratio of 4 or 5 to 1. The pumping head may also be constant or it may vary all the way from zero to a maximum. These are but some of the conditions to be met. In a sense their variety is infinite.

SITUATIONS CLASSIFIED

Yet, it is possible to mark out certain general classifications which more or less cover the entire ground and at the same time are sufficiently few in number for the mind to handle conveniently.

A. First, an installation may be classified according to its purpose which may be:

1. The building of an entirely new station at a new site.
2. The addition of capacity at an existing station required either by the growth of load or the wearing out of old equipment.
3. The installation of more efficient equipment in an existing station in order to effect economies.

B. Next, an installation may be classified as to the character of the service to be rendered, as for example:

1. Single pumpage of either raw water or clear water.
2. Double pumpage of both raw water and clear water.
3. Special services such as the pumpage of well water from the ground.

C. The next classification is according to the character of the load to be handled determined usually by the amount of reservoir capacity in the system into which the pumps discharge.

1. Uniform pumpage rates where there is a large reservoir sufficient to allow pumpage at a continuous rate for 24 hours or more. Here the peak load, which is due to seasonal variation, is about 25 percent greater than the average load.
2. A moderately varying pumpage rate where there is a small amount of reservoir capacity sufficient only to eliminate peaks of short duration and where the rate of pumpage must at least partly follow the changes in consumption during a single day. In such plants the maximum summer peak will be about 50 to 60 percent greater than the average rate of pumpage for the year.
3. Widely fluctuating pumpage rates, but practically uniform head, where there is no reservoir capacity and where, due to the pumpage having to follow the consumption, the peak will be about 2 to 3 times as great as the average and from 3 to 5 times the minimum.
4. Widely fluctuating pumpage rates combined with fluctuating head as, for example, where there is no reservoir and the pumpage is through a long transmission line so that the head rises rapidly with the pumpage rate or where it is necessary to raise fire pressure. In these cases the horsepower will vary even more widely than the pumpage rate due to the additional head superimposed upon peak pumpage rates. The peak horsepower may be 4 times the average and 5 to 6 times the minimum.

D. The final major classification is as to size. Here alone we meet with an infinite variety of situations, yet it is possible to make certain classifications, although these, of necessity, must be arbitrary.

A pump station being a power unit is more usefully classified in terms of horsepower of load than in terms of quantity of water pumped. Its task is that of pumping water against a head just as the task of the electric generating station is that of pumping electric current against a potential. In each case there is a rate of doing work and the proper unit of measure is power. A station which pumps a small quantity of water against a high head may have the same horsepower as one which pumps a large quantity against a small head. Two such stations are more comparable both as to type of equipment needed and cost of operation than are two stations which pump the same quantity of water against greatly different heads and, therefore, have greatly different horsepowers.

For the purposes of this discussion, therefore, pumping stations and equipment will be classified on the basis of the brake horsepower required to handle the load at the average rate of pumpage. The following classification will be used and the reason for this particular choice of capacities will be made clear later:

1. Average load more than 1200 BHP
2. Average load 600 to 1200 BHP
3. Average load 250 to 600 BHP
4. Average load less than 250 BHP

TYPES OF EQUIPMENT AVAILABLE

We have succeeded in classifying the situations to be met in the installation of new equipment into four major heads each of which is subdivided into either 3 or 4 subdivisions. Altogether there are more than 100 possible combinations of these groups of situations. To meet a particular one the water works engineer has many types of equipment from which to choose. These may be generally classified as follows:

1. Reciprocating Steam Pumps consisting of:
   Direct-acting or crank and fly-wheel pumps either horizontal or vertical, condensing or non-condensing, with simple, compound or triple expansion engines.
2. Steam turbine driven centrifugal pumps:
   Either direct-connected or gear driven with either non-condensing or condensing turbines of single or multiple stage; single barrel or compound; impulse or reaction type or combination of both. The pump may be single or multiple stage or have more than one stage connected either in series or in parallel and the unit may or may not be combined with a generator for operating station auxiliaries and smaller motor driven pumps.
3. Internal Combustion Engines, either Diesel, Gas or Gasoline, driving:
   Centrifugal or reciprocating power pumps either direct-connected or through gears.
4. Electric Motors driving:
   Either centrifugal or reciprocating power pumps. The motors may be either direct current or alternating current and, if alternating current, may be constant speed squirrel cage or synchronous motors, or variable speed slip-ring or brush-shifting motors.

5. Miscellaneous pumping equipment such as:
   Motor driven deep wells or air compressors for operating air wells or water turbines for operating pumps requiring only small amounts of power.

FOUR TYPICAL CASES TO BE EXAMINED

Having now formed some picture of the variety of circumstances to be met and of the equipment available, let us proceed to discover whether any one type is most suitable to all conditions or, if not, what circumstances are best suited to each type. To do this within the practical limits of this paper, we must make certain assumptions and short cuts. We will, for example, make four rather complete studies of four typical sizes of plant, one in each of the four sizes classified above. These studies will consist of comparisons of the cost of installing and operating steam equipment, Diesel equipment and electric motors using purchased power. We will first assume that each problem calls for the building of a new plant to pump single pumpage at a relatively uniform rate and then we will consider one after the other, what change would be effected in our results if, instead of single pumpage, both raw water and clear water had to be handled; if, instead of a uniform rate of pumpage, there was a widely fluctuating load and if, instead of a new station, the problem had called merely for adding new capacity to an old one.

To further simplify the task we will assume for all cases that the head is 300 feet; that the cost of coal is $3 per ton; that the cost of oil for Diesel engines is 6 cents per gallon; and that the cost of electric energy averages 1 cent per KWH including all demand and energy charges.

In the appendix will be found detailed tabulations of these four studies and curves showing approximate cost of equipment and building costs, all expressed on a unit horsepower basis. These figures are, of course, not exact, but give a close estimate of the average cost of installing and operating various types of structures and equipment. They assume reasonably good engineering and only sufficient overhead to include staff costs, but no profit. In the four sets of detailed comparative studies it is assumed that centrifugal pumps will be used in every case and the cost of the pumps, piping and pump pits being therefor the same, are neglected in order to concentrate on a comparison of the cost of the power units and that portion of the building necessary to house them. Since this separation is not possible with reciprocating pumps, the cost of the pumps is included

in the supplementary comparisons made between steam turbine installations and reciprocating steam pumps.

The four ranges of horsepowers into which the size groups are classified and with which the four detailed studies will deal have been selected on a basis suggested by the characteristics of steam plants. When a steam plant is large enough to require a turbine of more than 1500 horsepower highly efficient turbines are available at relatively low costs per horsepower. The load is sufficient to require stoker-fired boilers large enough to operate considerably above their rated capacity and so hold down the unit cost. The size of the installation and the fuel consumed is sufficient to justify steam pressures of 300 to 400 pounds and high superheat. At the other end of the scale are small plants using driving units of less than 300 horsepower capacity. Turbines in these sizes are inefficient and the more efficient types of reciprocating pumps are costly. The boiler load warrants nothing more than small return tubular hand-fired boilers for low steam pressures and operating at low efficiencies. In between these ranges the steam plant consists of moderate sized turbines of relatively good efficiency with small stoker-fired boilers of pressures not exceeding 250 pounds and operating only slightly above rated capacity. This field has arbitrarily been divided into two groups. In Diesel or motorized plants there is not this marked change with size in operating efficiencies and unit costs.

GROUP 1. AVERAGE LOAD ABOVE 1200 HORSEPOWER

For this group of a plant of 1600 horsepower average load is taken as typical. This corresponds to a pumpage rate of 25,000,000 gallons per day against 300 feet head. Since reservoir capacity is assumed sufficient to eliminate daily fluctuations, seasonal variations in consumption will determine the peak which should be about 25 percent above the average. Hence the maximum load will be 2000 horsepower. A steam plant will, therefore, need a 2000 horsepower turbine to operate at a pressure of, say, 300 pounds absolute and 150° F. superheat. This turbine operating between 1200 horsepower and 2000 horsepower at an average water rate of 8.4 pounds per horsepower hour would furnish a good load for a 400 horsepower stoker-fired boiler. The total investment required for the turbine, gear and condenser, including the condenser pit plus the boiler and one complete set of auxiliaries plus the necessary building for housing both turbine and boiler plant, would be about $128,000. The

turbine, however, must be duplicated; so also must the boiler and auxiliaries. The investment must, therefore, be double, making $256,000. To this must be added $20,000 to cover the cost of a stack and sufficient coal handling equipment to simplify coal handling. The total investment will be $276,000.

If, instead of a steam plant, Diesel engines are installed to meet the maximum load of 2000 BHP with one unit out of service, the Diesel installation could consist of (a) 2–2000 horsepower units, (b) 3–1000 horsepower units, of (c) 4–667 horsepower units. The second arrangement requires 1000 horsepower less than the first and would be much cheaper. The third arrangement requires only 300 horsepower less than the second and, due to the greater unit cost of each installation, the total cost would be about the same. There would be the further advantage in the three unit plant of having one engine less to take care of. The study is, therefore, based on installing three units. The investment required is $270,000.

If the plant is motorized it would be cheaper to install four units requiring approximately 667 brake horsepower each or, let us say, 4–700 horsepower motors. Due to the large reservoir capacity there is little danger due to outage of electric power service. Such outages are today of short duration except in very rare cases, where an unusual storm or fire has badly destroyed the power lines over a large distance. If the power plant is nearby and power lines come into the station from more than one direction, no independent source of power should be needed. If the generating station is distant or if there is only one power line leading to the station, one or two of the pumps should have independent driving units. In this study we have assumed that one pump is equipped with gasoline engine standby. The total investment required is $73,000.

A comparison of the cost of these three types of installation follows:

	STEAM	DIESEL	ELECTRIC
Investment	$276,000	$270,000	$73,000
Fixed Charges	41,400	40,500	11,000
Labor	21,600	14,400	10,800
Fuel or Energy	26,000	60,000	112,000
Total Annual Cost	$89,000	$114,900	$133,800

Note: Fixed charges include interest, taxes and an allowance for depreciation and all maintenance exclusive of labor performed by the regular operating crew. The total is 15 percent of the investment. See Appendix.

In this case the steam plant is very decidedly the most economical, the annual cost being about $26,000 per year less than the Diesel and about $45,000 per year less than the electric. If the plant is a municipal plant and there are no taxes the steam plant makes an even more favorable showing. The cost of coal would have to be increased 50 percent and the cost of oil reduced to 4½ cents a gallon, for the Diesel plant to make as good a showing as the steam plant. In the case of the motorized station, the cost of electricity would have to be reduced below 0.6 cent per KWH for the electric plant to do as well as the steam plant.

While there are exceptional cases where a power company would be willing to take on an average load as small as 1300 KW at a price less than 6 mills, this cannot be expected as the usual thing. The reason for this is that, at the majority of steam generating stations, the cost of power on the buss will hardly be less than 5 mills per KWH of actual output. To this must be added about ½ mill to cover transformer and transmission line losses and another ½ mill to cover fixed charges on the investment in transformers and transmission line. This brings the total to 6 mills delivered to the pumping station without any allowance for commercial expense and profit.

In general, therefore, plants in this group should be built for operation by steam, although there will be circumstances when either Diesel or purchased power may be justified.

GROUP 2. AVERAGE LOAD 600–1200 HORSEPOWER

Passing to the next smaller group, a similar comparison has been made. An average load of 800 brake horsepower is selected as typical with a maximum peak of 1000 BHP. This corresponds to an average pumpage rate of about 12,000,000 gallons per day against 300 feet. The steam plant consists of two 1000 horsepower turbines with two 270 horsepower stoker-fired boilers with the usual auxiliaries, buildings, stack, etc. The plant is designed to operate with a pressure at the turbine of 250 pounds absolute and 100°F. superheat. The Diesel plant consists of 3–500 horsepower engines and the electric plant of 3–500 horsepower motors and one 500 horsepower gasoline engine standby.

A comparison in this group summarizes as follows:

	STEAM	DIESEL	ELECTRIC
Investment	$185,000	$150,000	$47,000
Fixed Charges	27,800	22,500	7,000
Labor	17,000	10,200	8,500
Fuel or Energy	16,200	30,000	56,000
Total Annual Cost	$61,000	$62,700	$71,500

Here the comparison is closer. The Diesel plant is practically on a par with the steam plant and the electric plant has very considerably bettered its position in relation to both. A slight increase in the cost of coal or decrease in the cost of oil and the Diesel plant will make the best showing, whereas a reduction in the cost of power to 8 mills per KWH would give the electric plant the advantage over both.

GROUP 3. AVERAGE LOAD 250–600 HORSEPOWER

Passing to the third group, a plant with an average load of 400 horsepower corresponding to 6,000,000 gallons per day against 300 feet has been chosen. For the steam plant 2–500 horsepower turbines operating at 175 pounds absolute, 100°F. superheat are selected and two 175 horsepower water tube boilers with necessary auxiliaries, buildings, stack, etc. The Diesel plant consists of 3–250 horsepower engines and the motorized plant of 3–250 horsepower motors with one 250 horsepower gasoline engine standby. You will note that the unit cost of the 250 horsepower gasoline engine is lower than the larger engines used in Groups 1 and 2. This seems strange but is, nevertheless, true due to the fact that in the large sizes only engines of superior design and construction are available.

A comparison of the three types of plant in this group is as follows:

	STEAM	DIESEL	ELECTRIC
Investment	$135,000	$86,000	$22,500
Fixed Charges	20,200	12,900	3,400
Labor	14,400	8,000	6,400
Fuel or Energy	10,000	15,000	28,000
Total Annual Cost	$44,600	$35,900	$37,800

Even with coal at $2 per ton, the Diesel and electric plant would here have a decided advantage. To justify the building of a steam plant with coal at $3, the price of oil would have to be more than 10 cents and the price of electricity more than 1.25 cents per KWH. Except in rare cases, a new steam plant of this size could not be justified and the choice would ordinarily lie between the Diesel and the electric plant.

GROUP 4. AVERAGE LOAD BELOW 250 HORSEPOWER

In our final study of the small plant, a plant with an average brake horsepower of 160 has been selected as typical. This corresponds to an average of 2,500,000 gallons per day against 300 feet.

A comparison of the three types of plant is as follows:

	STEAM	DIESEL	ELECTRIC
Investment	$80,000	$40,000	$10,000
Fixed Charges	12,000	6,000	1,500
Labor	10,500	6,000	4,500
Fuel or Energy	5,000	8,000	11,600
Total Annual Cost	$27,500	$20,000	$17,600

As is to be expected, the steam plant has passed practically out of the picture. Oil would now have to be about 12 cents per gallon and electricity nearly 2 cents per KWH for a steam plant to come back in. The electric plant has gained an advantage over the Diesel, but the cost of power must be held below 1.2 cents per KWH to maintain an advantage and less than that if oil costs less than 6 cents per gallon.

SUMMARY OF THE FOUR TYPICAL CASES

1. When a new plant is to be built for a single pumpage at a nearly uniform rate a steam plant will usually be the most economical provided the load is sufficient to call for turbines of more than 1500 horsepower capacity.

2. For similar plants with loads averaging less than 250 horsepower the electric plant will ordinarily be most economical, but, if the power rates are high, the Diesel plant will be better.

3. In between these the field is highly competitive for the three

types of equipment with the Diesel having ordinarily a slight advantage which tends to give way to the steam plant in the upper ranges and to the electric plant in the lower ranges.

EFFECT OF DOUBLE PUMPAGE

So far we have assumed in these four studies that the water is to be pumped only once. If, however, the plant to be built will require double pumpage, first of raw water against a low head, then of filtered water against a high head, the relative costs of the three types of plants are hardly changed. If the low service pumps must be placed in a pit low enough to get suction the size of this pit, would, in each of the three types of station, be practically the same for in every case it is more economical to install motor driven or water turbine driven low service pumps, furnishing the power for these units, in the case of the steam and the Diesel plant, from water pumped by the main unit or by a small generator driven from the main unit. The cost of the motor driven low service pumps will in every case be the same. In the steam and Diesel plants there would be the added cost of two small generators or of slightly larger high service pumps than would ordinarily be needed.

Assume, for example, that one-fifth of the total head is low service. Then, in Group 1, the added investment would be not more than $15,000 for the steam and Diesel plant. This would add to fixed charges, and hence to the total, $2250 per year. This would not change the relation between the steam plant and the Diesel plant but would merely reduce the difference between the steam plant and electric plant from $45,000 to about $43,000 per year.

In Group 2 the investment for the steam plant and the Diesel plant would be increased about $10,000 each, increasing the fixed charges and hence the total about $1500 each. Again the relation is not changed between the steam and the Diesel plant and would but slightly improve the opportunity of the electric plant.

In Group 3 the additional investment would amount to about $6,000, increasing the fixed charges $900 per year for the steam and Diesel plant. This would make the steam plant, which is already the most expensive, slightly more expensive and would better slightly the standing of the electric as compared with the Diesel.

In Group 4 the investment added is $3,000, causing an annual increase of about $400 for the steam and Diesel plant which are already the more expensive plants.

EFFECT OF FLUCTUATING LOAD

In the four typical cases we have assumed that the load is quite uniform due to the large reservoir capacity. If, however, there is little or no reservoir capacity and the peak load is anywhere from one and one-half to two or three times the average load, this will have a greater influence on the results than having to provide for double pumpage. Since the average load will be unchanged, the average power required, and hence the average operating expenses, will remain pretty nearly the same except for a very slight increase in fuel consumption due to the greater variations in the pumpage rate and perhaps a more appreciable increase in energy cost for the electric plant due to the greater demand charge. The chief effect, however will be upon the fixed charges because there will be a greater investment to take care of the greater peaks. To investigate the effect on these fixed charges, let us assume that the peak load is twice the average load.

In Group I the maximum load will be 3200 horsepower. The investment in the steam plant would be increased by nearly one-third and in the Diesel plant by slightly more than one-third. This will increase the fixed charges in each case $13,000 to $14,000 per year. The fixed charges for the electric plant will be increased not more than half this amount, but the difference between the total cost of the steam plant and the electric plant was previously $45,000 per year. Hence the steam plant remains decidedly in the lead.

In Group 2 we must proceed more carefully. The peak load will be 1600 horsepower. In the steam plant a third turbine and boiler must be installed, although the third turbine need be only 600 horsepower. The additional boiler will cost about $38,000 and the turbine about $32,000 making a total of $70,000. Fixed charges on this will be $10,500 per year. In the case of the Diesel plant the capacity will be increased one-third, hence the investment and fixed charges one-third or $7,500 per year. In the case of the electric plant the three motor driven units must be increased to four and each must be slightly larger. Two additional gasoline engine standbys must be added. This increases the total investment $55,000 or more than doubles it, adding fixed charges of $8,300 per year.

The total annual cost for the three types of plant now compare with each other and with the former set-up for this group as follows:

	UNIFORM LOAD	FLUCTUATING LOAD
Steam	$61,000	$71,500
Diesel	62,700	70,200
Electric	71,500	79,800

The Diesel plant has gained by this new situation.

In Group 3 the investment for the steam plant will be increased 40 percent, increasing the fixed charges $8,000 per year. The investment for the Diesel plant would be increased one-third, increasing the fixed charges $4,300 per year. The electric plant investment would be increased $12,500 and the annual charges $1900. The total annual cost of these three types of plants, both with uniform load as in the original study and with fluctuating load as in this revision, will then compare as follows:

	UNIFORM LOAD	FLUCTUATING LOAD
Steam	$44,600	$52,600
Diesel	35,900	40,200
Electric	37,800	39,700

The steam plant has now been shoved pretty definitely out of it and the electric plant has changed places with the Diesel.

In the 4th group, the small plants, the same thing will occur as in the 3rd group. The steam plant, already out of the running, will, on account of its larger investment, be put further back while the electric plant will be given a still further advantage over the Diesel.

Thus we may say that changing from a uniform load to a load with high peaks has penalized those types of plant requiring a large investment. In the large stations steam still retains a considerable advantage, but loses ground to the Diesel as the size is reduced. The Diesel in turn loses ground to the electric plant as the horsepower is still further reduced. The electric plant, however, cannot benefit by its advantage if the rates are such that the increased demand has too great an effect.

EFFECT OF ADDING EQUIPMENT TO AN EXISTING PLANT

If, instead of building a new plant, the problem is to add to an existing one, the effect on the results of our four original studies is even more marked and in the opposite direction. The type of equip-

ment requiring the greatest investment will not be so heavily weighed down with fixed charges because there will not be so much equipment needed and the advantage of low operating cost will become more conspicious.

Let us assume that we have an existing steam plant and that, due to the wearing out of old equipment or to its extremely inefficient operation and also, perhaps, to an increase in load, it is necessary to install a new unit large enough to carry the average load. We will assume further that, if a new steam unit is installed it will also be necessary to install a new boiler and building additions, but that the stack and coal handling facilities are adequate. It may be found, however, more advantageous to install a Diesel engine for this main unit maintaining the existing steam equipment as standby or to take this opportunity to electrify the plant. We shall now look into these possibilities.

For obvious reasons Group 1 plants need not be considered.

In the case of Group 2, a 1000 horsepower turbine and 270 horsepower boiler with auxiliaries and building can be installed for $85,000, making the total for fixed charges $12,750 per year. The total for labor and fuel will be the same as before. A 1000 horsepower Diesel installation will cost $90,000. On account of having to maintain the steam equipment and perhaps keep a boiler banked, at least two more men will be required than with an all Diesel plant, increasing the total for labor to $13,600. The fuel cost will be the same as in the all Diesel set-up. For an electric plant large enough to take care of the load, but using the steam plant for standby, the investment will be only $18,000 but the labor would be increased to seven men or to $11,900. The total annual cost of the three plants compared with the same figure for the original studies will be as follows:

	ENTIRE NEW PLANT	NEW UNIT ONLY
Steam	$61,000	$47,100
Diesel	62,700	55,600
Electric	71,500	70,600

The steam plant has gained a decided advantage over the Diesel and the electric plant is no longer competitive.

In the case of Group 3 similar changes produce the following comparison:

	ENTIRE NEW PLANT	NEW UNIT ONLY
Steam	$44,600	$33,400
Diesel	35,900	34,200
Electric	37,800	37,800

(In this case, due to the small amount of equipment needed, the electric plant is assumed to be completely electrified in order to reduce labor. The operating force of the Diesel plant has been increased from 5 to 6.)

Here we see that the steam plant formerly at a great disadvantage has moved into first place.

In Group 4, where, it will be recalled, the average load is only 160 horsepower and the pumpage rate about 2,500,000 gallons per day, the comparison is as follows:

	ENTIRE NEW PLANT	NEW UNIT ONLY
Steam	$27,500	$20,900
Diesel	20,000	17,900
Electric	17,600	17,200

It is surprising to note how in even so small a plant as this where, in the set-up for a new plant a steam plant was not in the running at all, there is not now a very great deal to be saved by changing to Diesel or electric drive. In fact, the power rate need be only 1.3 cents per KWH or the cost of oil 8 cents to wipe out any advantage which these installations have over the steam.

Hence, we may conclude that, if the problem is to make an addition to an existing steam plant rather than to build an entirely new one, steam operation has a very considerable tenacity for holding its own even down into the very small sizes. The Diesel engine ordinarily has no place of advantage in this type of situation, but enters the field in the smaller installations where coal is expensive and electric energy above 1½ cent per KWH.

There are, however, other considerations where a plant is to expand which have not so far been mentioned but which materially affect the answer in any particular case. Some of these are so important that they deserve particular emphasis. For example:

1. If an existing plant has equipment which is reasonably efficient and in good condition for handling normal loads and simply needs additional capacity to handle peaks due to a growing load, a standby

motor driven pump, due to the low investment required, may quite easily prove to be the best solution even in plants as large as Group 2. Or, if the charge for standby power is high a Diesel may make an excellent standby installation particularly in the smaller plants of Group 3 and 4 where Diesel installations per horsepower are cheaper than steam.

2. If the new equipment is needed for regular pumping and the existing steam equipment which is to be used for standby is all old and not in very good shape, the results shown by considering the new installation only should be modified. In other words, if it is going to be necessary also to install standby equipment in a few years, due to condemnation of boilers and the like, the problem should be considered more in the light of building a new plant than in that of installing a new unit only.

3. Finally, there are many small plants with a capacity of less than 100 horsepower which, when the occasion arises to put in new equipment, can often be most conveniently electrified for the simple reason that any saving that could be effected by the more elaborate steam or Diesel plant is not, under certain circumstances, worth the trouble.

RECIPROCATING PUMPS

In all of these comparisons the steam plants have been considered as equipped with steam turbine driven units. There are, however, circumstances under which it may be more desirable to install a reciprocating pump. In the larger plants of Group 1 and Group 2 this would not be the case because a turbine driven centrifugal pump would have practically as good an efficiency as any type of reciprocating pump and the cost of the reciprocating pump would be very much more. Even in the plants of the Group 3 size the turbine installation is most likely to prove the best. If, instead of the 500 horsepower turbine unit in the Group 3 case, a crank and fly-wheel pump had been installed the efficiency would not be more than 15 percent better and the fuel consumption a corresponding amount less. The total fuel cost in this case was only $10,000, hence the saving would be $1500 per year. On the other hand, a single crank and fly-wheel pump of the same capacity would cost installed, together with the larger building needed, $15,000 to $20,000 more than a single turbine unit. This would mean an increase in fixed charges of $2250 to $3000 per year or nearly twice the saving in fuel.

In the fourth group, however, there are cases where a reciprocating

pump will show up about as well as a turbine driven installation. The efficiency of the small turbine is such that a crank and fly-wheel pump could do the work with about 30 percent less coal, effecting a saving of about $1500 per year. The extra cost of the crank and fly-wheel pump, including a larger building, would be about $12,000 requiring an increase in fixed charges of $1800 per year. If there are no taxes to be included the increase in fixed charges would be the same as the decrease in fuel and, even if taxes are included, the difference in annual cost between the two units is so small that whichever type is most suitable to the conditions of service should be selected. For example, if fire pressure is to be raised, the reciprocating pump might be the more suitable.

The installation of new reciprocating pumps is practically limited to the efficient crank and fly-wheel type because the direct-acting pump is less efficient than turbine units even in the Group 4 class and slightly more expensive.

Since the building of new steam plants in the class 4 Group is practically never feasible, we may conclude that there will be few, if any, cases where reciprocating pumps will be installed in new stations. This, of course, limits the installation of new reciprocating pumps to only a portion of the cases falling under Group 4 where additions are to be made to an existing plant and, due to the high local cost of Diesel oil and electric energy, steam equipment of some kind can be justified. This is naturally a small field. It would be folly, however, to assume that, having already made the investment in a highly efficient crank and fly-wheel pump, any other type of steam equipment could be installed for the purpose of saving fuel. For this reason we can look forward to seeing a number of these pumps in operation for a good many years.

SUMMARY

We have passed in a review a large variety of situations to be met in the installation of new pumping equipment. We have attempted to classify these situations and to show that under one set of circumstances one type of equipment generally had an advantage and in another set of circumstances another type generally had the advantage. Hardly anywhere, however, have we found that any type of equipment has an undisputed field. Even in the cases where one type of equipment seemed to have the greatest advantage over the others, our analysis showed that a change from what might be con-

sidered an average in the cost of coal, of oil or of electric energy, would make another type more suitable.

In general we found that for a new plant having a uniform pumpage rate a steam plant generally had quite an advantage, provided the plant was large enough to justify the installation of a turbine of more than 1500 horsepower. On the other hand, if the horsepower required were less than 250 or 300 the electric plant generally had an advantage. In between these sizes the Diesel plant had a slight advantage but was closely competitive with steam as the sizes approached the upper limit and with electricity as the sizes approached the lower limit.

We found further that whether the pumpage was single or double pumpage made very little difference.

We next found that, if the load was not uniform or, in other words, if there were large peaks to be met, the sizes in which steam plants could be justified, other things being equal, had to be larger and the sizes in which electric plants could be justified were also larger. In other words, the lower investment equipment moved up the scale.

Finally we found that, if, instead of building a new plant, the problem was merely to add equipment to an old one, the effect was the reverse of the preceding effect and that a steam unit could generally be justified in much smaller plants and so also Diesels, as compared with electric installations, could be justified in smaller plants. In this case the equipment requiring a greater investment per horsepower is given a better opportunity due to the fact that less of it is needed.

I hope that the point of view developed in this paper and the figures given in the appendix may be helpful to water works engineers in their preliminary studies on pumping station problems. The figures are, of course, average figures as a study of this kind could not be based on either the highest or the lowest prices for which equipment can be installed and operated.

DISCUSSION

H. R. CADY[3]: Mr. Pigman has presented a very valuable paper showing as it does a set-up covering the various factors involved in comparison of different types of pumping equipment. It also forms a valuable reference in showing the trend of comparative economy assuming representative sets of conditions.

[3] Mechanical Engineer, Hackensack Water Company, Weehawken, N. J.

I should like to emphasize the prime importance in every case, where a decision is to be made regarding choice of equipment, of making a detailed analysis which is strictly our own and takes into consideration all of the various operating conditions in our particular systems, and of setting these up to show their actual relative value over a period of years. We need the manufacturer's data based on the best equipment he can furnsh to meet our conditions and we need full data on current costs, fuel costs, etc., but it is hardly possible for the material man, the power man and the coal man, to get the unbiased perspective of the man who will pay the bills.

The value of these various factors and the final set-up to show comparative economy must necessarily be made by engineers of the municipality or water company, either regularly employed or called in for the special work involved. If possible, I believe it would be best on any major project to have both a consultant's report and a thorough check by the engineering department.

APPENDIX

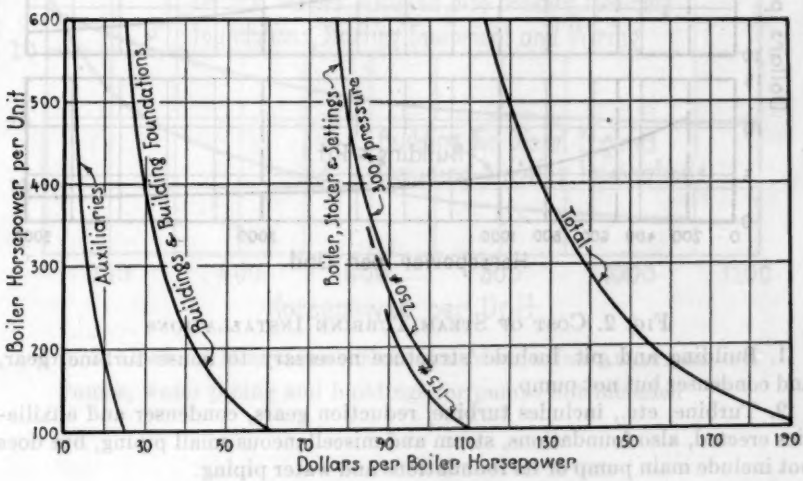


FIG. 1. COST OF BOILER PLANT

1. Auxiliaries include one each, feed pump, stoker fan and duct, closed heater and piping also steam piping and breeching connections.

2. Building is based on one-half the cost of building large enough for two boilers.

3. Boiler stoker, and settings include superheater, soot blowers and boiler foundations.

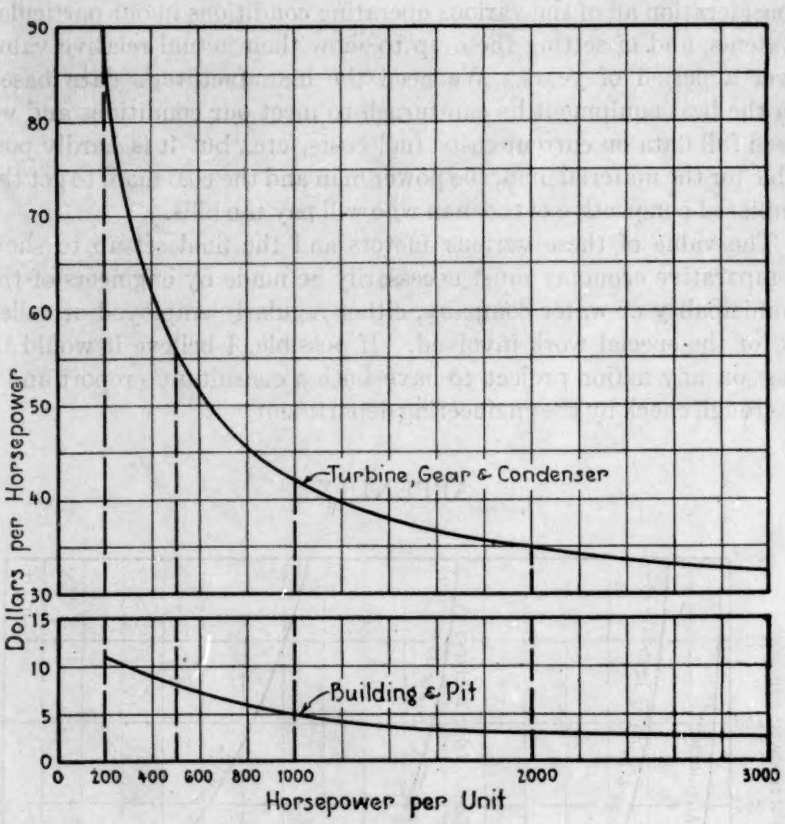


FIG. 2. COST OF STEAM TURBINE INSTALLATIONS

1. Building and pit include structure necessary to house turbine, gear, and condenser but not pump.

2. Turbine, etc., includes turbine, reduction gears, condenser and auxiliaries erected, also foundations, steam and miscellaneous small piping, but does not include main pump or its foundations and water piping.

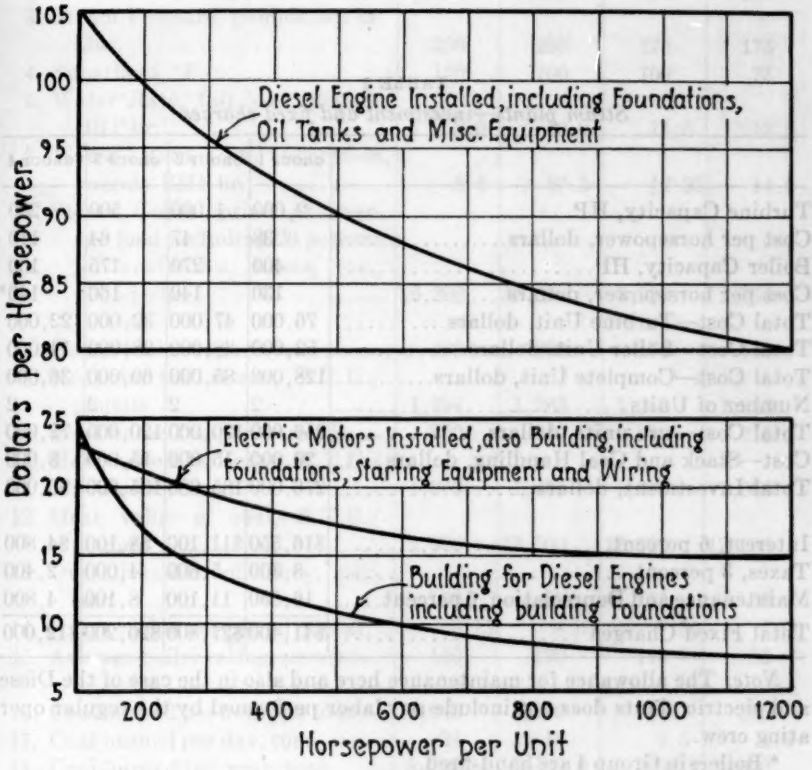


FIG. 3. COST OF DIESEL AND ELECTRIC MOTOR INSTALLATIONS
Pumps, water piping and buildings for pumps not included

TABLE 1

Steam plants—investment and fixed charges

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Turbine Capacity, HP	2,000	1,000	500	200
Cost per horsepower, dollars	38	47	64	110
Boiler Capacity, HP	400	270	175	100
Cost per horsepower, dollars	130	140	160	140*
Total Cost—Turbine Unit, dollars	76,000	47,000	32,000	22,000
Total Cost—Boiler Unit, dollars	52,000	38,000	28,000	14,000
Total Cost—Complete Unit, dollars	128,000	85,000	60,000	36,000
Number of Units	2	2	2	2
Total Cost—two units, dollars	256,000	170,000	120,000	72,000
Cost—Stack and Coal Handling, dollars	20,000	15,000	15,000	8,000
Total Investment, dollars	276,000	185,000	135,000	80,000
Interest, 6 percent	$16,550	$11,100	$8,100	$4,800
Taxes, 3 percent	8,300	5,600	4,000	2,400
Maintenance and Depreciation, 6 percent	16,550	11,100	8,100	4,800
Total Fixed Charges	$41,400	$27,800	$20,200	$12,000

Note: The allowance for maintenance here and also in the case of the Diesel and electric plants does not include any labor performed by the regular operating crew.

* Boilers in Group 4 are hand-fired.

TABLE 2

Steam plants—operating costs

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Fuel Cost:				
1. Average Load on Turbine, BHP.	1,600	800	400	160
2. Turbine Capacity, BHP.....	2,000	1,000	500	200
3. Steam Pressure, pounds/sq. in. abs.....	300	250	175	175
4. Superheat, °F.....	150	100	100	75
5. Water Rate, full load, pounds/ BHP hr.....	8.0	10.0	11.5	13.5
6. Water Rate, Av. operation, pounds/BHP hr.....	8.4	10.5	12.25	14.2
7. Steam Consumption at average load including 20 percent for auxiliaries, losses, etc., pounds/hr.....	16,200	10,000	5,900	2,700
8. Rated boiler capacity.....	400	270	175	100
9. Heat in the steam, B.T.U./ pounds.....	1,294	1,263	1,253	1,240
10. Feed water Temperature, °F.....	250	240	210	210
11. Heat added in Boiler, B.T.U./ pound.....	1,076	1,075	1,075	1,062
12. Heat value of coal, B.T.U./ pound.....	12,500	12,500	12,500	12,500
13. Overall boiler efficiency, percent.....	70	68	65	60
14. Evaporation per pound of coal...	8.15	8.00	7.50	7.00
15. Average boiler rating, percent...	130	120	110	85
16. Coal burned per hour, pounds...	1,940	1,250	790	385
17. Coal burned per day, tons.....	24	15	9.5	4.6
18. Coal burned per year, tons.....	8,700	5,400	3,300	1,670
19. Cost of coal per ton, dollars.. ...	3.00	3.00	3.00	3.00
20. Annual cost of coal, dollars.....	26,000	16,200	10,000	5,000
Labor Cost:				
21. Number of Operators.....	12	10	9	7
22. Average Yearly Wage,* dollars.	1,800	1,700	1,600	1,500
23. Annual Labor Cost, dollars.....	21,600	17,000	14,400	10,500

* Average yearly wage is decreased for smaller plants because these plants are usually in smaller localities and also because the responsibilities are less. The same holds for the Diesel and electric plants.

TABLE 3

Diesel plants—investment and fixed charges

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Capacity of Engines, HP	1,000	500	250	100
Number of Engines	3	3	3	3
Total Installed, HP	3,000	1,500	750	300
Cost per horsepower, dollars	90	100	115	130
Total Investment, dollars	270,000	150,000	86,000	40,000
Interest, 6 percent	$16,200	$9,000	$5,160	$2,400
Taxes, 3 percent	8,100	4,500	2,580	1,200
Maintenance and Depreciation, 6 percent	16,200	9,000	5,160	2,400
Total Fixed Charges	$40,500	$22,500	$12,900	$6,000

TABLE 4

Diesel plants—operating costs

For Engines of Groups 1, 2 and 3:

Cost of oil $0.06 per gallon

Weight of oil, 8 pounds per gallon

Fuel Consumption at average load 0.5 pound per BHP hour

Cost of oil per BHP hour is, therefore, $0.00375

Adding 15 percent for lubricating oil brings total to $0.0043

For Engines of Group 4:

Due to smaller size cost per BHP hour assumed to be $0.0046

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
1. Average load, HP	1,600	800	400	160
2. Fuel cost per BHP hour, dollars	0.0043	0.0043	0.0043	0.0046
3. Fuel cost per hour, dollars	6.90	3.45	1.72	0.735
4. Fuel cost per year, dollars	60,000	30,000	15,000	8,000
5. Number of operators	8	6	5	4
6. Average yearly wage, dollars	1,800	1,700	1,600	1,500
7. Annual Labor Cost, dollars	14,400	10,200	8,000	6,000

TABLE 5

Electric plant—investment and fixed charges

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Size of Motors, HP	700	500	250	100
Number of Motors	4	3	3	3
Installed Motor, HP	2,800	1,500	750	300
Cost per horsepower, dollars	16	18	20	23
Size of Gasoline Engine, HP	700	500	250	100
Number of Engines	1	1	1	1
Cost of Engines per HP	40	40	30	30
Total Cost—Motor, dollars	45,000	27,000	15,000	7,000
Total Cost—Engine, dollars	28,000	20,000	7,500	3,000
Total Investment, dollars	73,000	47,000	22,500	10,000
Interest, 6 percent, dollars	4,400	2,800	1,350	600
Taxes, 3 percent, dollars	2,200	1,400	700	300
Maintenance and Depreciation, 6 percent, dollars	4,400	2,800	1,350	600
Total Fixed Charges	$11,000	$7,000	$3,400	$1,500

TABLE 6

Electric plants—operating costs

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Average load, HP	1,600	800	400	160
Average motor efficiency	0.93	0.93	0.93	0.90
KW Input	1,280	640	320	133
Cost per KWH,* dollars	0.01	0.01	0.01	0.01
Cost per hour, dollars	12.80	6.40	3.20	1.33
Cost per year, dollars	112,000	56,000	28,000	11,600
Number of Operators	6	5	4	3
Average yearly wage, dollars	1,800	1,700	1,600	1,500
Annual Labor Cost, dollars	10,800	8,500	6,400	4,500

* With this load factor, which is 80 percent, this cost of one cent per KWH corresponds approximately to $1.25 per month per KW of demand plus an energy charge of 0.8 cents per KWH.

PIPE TUNNELS UNDER RAILROAD TRACKS[1]

By Lawrence G. Lenhardt[2]

The placing of water pipe in pipe tunnels under railroad tracks can be justified, first, where this is the least expensive method of construction; second, where the difficulty of constructing an open cut line would be such as to outweigh the difference in cost; and third, where ease and speed of maintenance and repair is of major consideration.

Under ordinary conditions, the open cut method is usually cheaper than tunneling under tracks. However, there are some conditions where the tunneling method is cheaper. Where a good tunneling soil or sound rock underlies a wet sand frequently a tunnel will be found the least expensive. Likewise, when a high fill has to be penetrated or where there is a large number of tracks, a comparison of costs will probably be in favor of the tunneling method.

When grade separation is to be expected, particularly in the near future, it is well to consider the advisability of placing the pipe in tunnel. Where a street is to be depressed, sometimes the cost of deep trench construction will be equal to or greater than that of a pipe tunnel. Where a pipe line is set comparatively shallow with the thought of lowering later, as is frequently done, the cost and attendant trouble may make a tunnel desirable. Furthermore, in such a case, there is usually difficulty from breakage due to impact from pile driving or to excavations close to the pipe line.

In estimating costs of a pipe tunnel, it is well to remember that usually either deep trench approaches or shafts must be provided at both ends of the tunnel. In figuring the costs of a pipe trench across trackage there must be considered not only the costs of supporting the tracks, but also the fact that unit costs of excavation under such conditions are considerably higher than under normal conditions.

Where soil conditions are good and trenches do not exceed 30 inches in width and 6 feet in depth, the cost of supporting a track

[1] Presented before the Central States Section meeting, September 19, 1929.

[2] Assistant Engineer of Land Tunnels, Department of Water Supply, Detroit, Mich.

with rail supports will probably be about 25 dollars. Under such conditions, the trench method is by far the cheaper. Where conditions are not so favorable, as where a large pipe is to be placed or where poor soil conditions and high speed main line trackage are encountered, the cost of track supports increases enormously. Mr. Bebb, the Bridge Engineer of the Michigan Central Railroad, has prepared the sets of curves shown on figure 1, based on trenches 7 feet wide where the pile trestle type of support has to be used. Necessarily the curves are only a guide because of varying conditions, but nevertheless they give a good working basis for estimates.

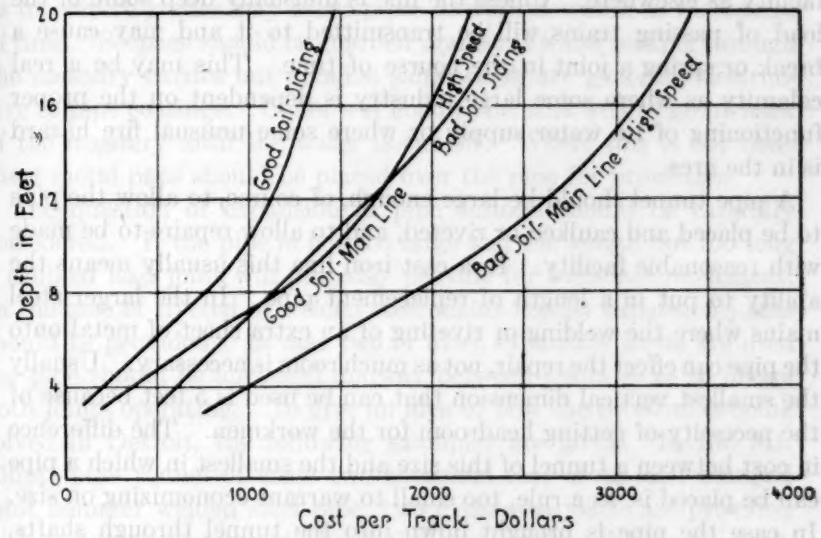


FIG. 1. ESTIMATED COST OF SUPPORTING TRACKS FOR INSTALLING PIPES, SEWERS AND CONDUITS

Note: Estimates based on trenches 7 feet wide, pile trestles to be used

Where a heavily traveled main line or busy yard is to be crossed, frequently it is not so much the question of cost as it is the expediency of getting through. Railroads have a marked disinclination to having such lines disturbed, particularly if a wide trench has to be dug. Furthermore, the maintenance of a pipe line under such a condition is exceedingly difficult and costly and must be considered.

The Detroit Water Board had an aggravated case of the foregoing recently where a 60-inch steel pipe line was to be placed on Central Avenue across the Michigan Central R.R. Twenty-four tracks had to be crossed including two main line tracks. All but

one of the remaining tracks were put to heavy usage such as hump and classification tracks. With the further considerations of a grade separation in the near future and poor soil conditions, construction of a pipe tunnel was clearly indicated and plans are now being prepared.

In the case of an area separated from a pumping station by a railroad track the original cost of installation is often outweighed by the necessity of keeping uninterrupted service, particularly if the area is to be served by no more than a single line. Needless to say a break under a railroad track is not repaired with the same facility as elsewhere. Unless the line is unusually deep some of the load of passing trains will be transmitted to it and may cause a break or spring a joint in the course of time. This may be a real calamity as where some large industry is dependent on the proper functioning of its water supply or where some unusual fire hazard is in the area.

A pipe tunnel should be large enough, of course, to allow the pipe to be placed and caulked or riveted, and to allow repairs to be made with reasonable facility. In a cast iron line this usually means the ability to put in a length of replacement pipe. In the larger steel mains where the welding or riveting of an extra sheet of metal onto the pipe can effect the repair, not as much room is necessary. Usually the smallest vertical dimension that can be used is 5 feet because of the necessity of getting headroom for the workmen. The difference in cost between a tunnel of this size and the smallest in which a pipe can be placed is, as a rule, too small to warrant economizing on size. In case the pipe is brought down into the tunnel through shafts, beveling the intersection of the crown of the tunnel with the shaft will allow the pipe to be entered with greater facility and may make possible saving in the size of the tunnel. If nothing else, beveling makes possible the use of longer pipe which is always desirable in this case.

The minimum clearances adopted in the Detroit area are 8 inches for cast iron and 12 inches for steel. In order to get at the bottom of the pipe it is necessary to support it above the tunnel floor. The supports should be of a permanent nature so as to allow easy inspection and maintenance. Channels, I-beams or angles back to back embedded in the masonry a sufficient distance above the invert to allow working space underneath, are the usual practice. Creosoted pillow blocks should be placed on the supports to carry the pipe.

The pillow blocks should be prevented from sliding on the supports during the expansion or contraction of the pipe. Placing the pipe on supports also gets the pipe out of such water that collects on the tunnel bottom and allows free drainage.

A pipe tunnel should always be placed on a grade so as to allow easy drainage. The grade should preferably be all to one end so that only one sump and pumping unit is necessary. It is usually desirable to provide the sump with float control so that the inevitable seepage water and drippings from the joints may be promptly disposed of. Grades should be as easy as is compatible with good drainage as too severe grades may cause pipes to work downhill in the course of time. Seepage should be guarded against as water leaking through the masonry carries out alkaline salts which are generally destructive to pipe coatings. Under wet conditions, it is well to grout back of the masonry until the water is cut off. Where this is not done sheet metal pans should be placed over the pipe for protection.

The question of expansion in pipe tunnels should be carefully considered. If the pipe is not too large and the length not too long a caulked lead joint will probably provide for sufficient movement. In the case of riveted or welded steel mains regular expansion joints should be provided. In case two or more expansion joints are used the pipe should be anchored midway between joints so as to insure both joints operating. To give an idea of how the problem is being solved in Detroit, the following examples are given. In the Mt. Elliott pipe tunnel of some two thousand feet of 48-inch bumped joint hammer welded steel pipe, two expansion joints are provided with a concrete pier cast about the pipe midway between joints. Slightly more than 1-inch expansion has been observed in each joint. In the Central Avenue tunnel with some twelve hundred feet of 60-inch steel pipe, two expansion joints will be provided with anchorage midway between. In the Dix Avenue tunnel, with 417 feet of 36-inch steel pipe with Matheson joints, no expansion joints are provided. In this latter case each joint will be held in place with a steel band fastened around the spigot end of the pipe and butting up tightly against the lead to prevent its working loose.

Walkways should be provided through the length of the tunnel. These may consist of either one or two planks on either or both sides of the pipe. The planks should preferably be creosoted and fastened to the pipe supports. Electric lights and moisture proof cables should be specified. In this connection it should be remembered to make

the cables heavy enough to allow power outlets for construction and maintenance work.

Hangers embedded in the masonry over the joints add considerably to the facility with which pipe can be placed or repaired. In the case of larger and heavier pipe a monorail beam fastened in the crown simplifies the handling and laying problem. With heavy pipe the masonry lining should be designed to take care of this load.

The lining thickness depends on many different factors such as depth of tunnel, character of material to be tunneled, the kind and quality of masonry used, and more than anything else, on the standards of the railroads under which the tunnel passes. As most railroads are quite conservative, it is well to assume that lining thicknesses for circular tunnels will be approved by the railroads for normal conditions as follows:

Up to 6 feet in diameter:	10 inch concrete or 3 rings of brick
From 6 to 9 feet in diameter:	14 inch concrete or 4 rings of brick
From 9 to 12 feet in diameter:	18 inch concrete or 5 rings of brick

DISCUSSION

C. E. INMAN:[3] Some railroad companies go so far as to say that the casing shall be the entire width of the right of way. I have always contended that it is very bad practice to put a casing under a right of way and then to slide a water pipe through it and let the pipe ride on the bottom of the casing. The water pipe gets as much vibration from that casing as though it were put through without a casing at all. I have convinced them in some cases that, if the water pipes were put through the casing and supported between the tracks, the vibration would be eliminated.

G. GALE DIXON:[4] Mr. Inman's remarks gave me a thought. We are carrying a 20-inch cast iron pipe into Niles, a small neighbor of Mr. Inman's city of Warren. We have to cross roads as well as railroads. In making a request for a permit to cross the tracks under one main line railroad, the railroad sent our sketches back and asked that the pipe be slid inside of a large wrought iron pipe on the outside. I cannot imagine anything worse to do. If you do get a break in that pipe you are absolutely lost. What we are doing is to build a tunnel.

[3] Commissioner and Superintendent, Water Works, Warren, O.
[4] Office Engineer, The Mahoning Valley Sanitary District, Youngstown, O.

O. A. McCarthy:[5] Mr. Inman's remarks about casings around water mains calls to mind that we have a 12-inch water main across the Michigan Central right of way in Dearborn. We did not know how we were going to put that through. They would not accept a concrete casing. I suggested a steel casing and jacked it through. It seemed to be all right with the railroad company, so we took a 36-inch welded steel pipe and jacked that through with a one hundred ton jack. Of course we dug out 6 inches from the pipe and took the mud out by means of a child's sleigh. We put in about eight feet per day. The length of pipe is 45 feet. You could get in there and caulk all joints.

[5] Commissioner of Water Supply, Fordson, Mich.

CEMENT LINING GALVANIZED PIPE IN WEST PALM BEACH[1]

By Ralph W. Reynolds[2]

The Palm Beaches obtain their water from a surface supply which is quite soft and has always been more or less corrosive to metal pipe. With the improvement of the source of supply the tendency has been constantly toward a softer quality of water, with the result that in recent years the question of corrosion has taken on the proportions of an important problem.

In 1925 the Company, therefore, adopted a definite policy of using only cement lined cast iron mains. At the present time about 60 percent of the Company's cast iron distribution system comes under this classification. The Company, however, has about 75 miles of galvanized iron distribution system, some of which is only a few years old, but a very large proportion of which has an age of more than 10 years. This old pipe is showing very heavy deterioration and we have had experience with even the newer pipe developing considerable red water trouble, so that the policy of using only cement lined pipe for replacing the old galvanized mains when replacement become necessary has been adopted.

It was not considered practical in our case to purchase cement lined pipe, one of the most important reasons being that as our cast iron system was extended a great deal of galvanized pipe in a good state of preservation became subject to salvage at a very low cost. It was felt that if a cheap method of cement lining could be developed it would pay us to salvage this pipe in replacing the old galvanized mains. Therefore, in the summer of 1926 we started a series of experiments, mostly along "cut and try" lines, which has finally led to a method of lining which, while it does not produce as perfect a lining as can be purchased in the market, is still very satisfactory to use and has proved quite cheap. Such a method may be useful to other utilities of moderate size, which may have problems similar to our own and the method is submitted with that end in view.

[1] Presented before the Toronto Convention, June 28, 1929.

[2] Superintendent, West Palm Beach Water Company, West Palm Beach, Fla.

Our cost averages 2½ cents per lineal foot for all sizes from 1 to 2 inches, which is the range over which we are working. This cost of course requires some qualification. It is bare "out of pocket" cost. It carries very little overhead burden and very little cost of supervision. From our viewpoint computing the cost in this way is justifiable for the work is done at odd times when work for our maintenance force is somewhat short. Our maintenance personnel is maintained at a minimum below which we do not dare to go and at times it is necessary for us to find work for these men to do. A large utility finding it necessary to employ a special crew with necessary supervision to carry on cement lining operation would probably find its cost running somewhat higher than ours, although this might very probably be offset by the low cost of quantity of production.

The method finally developed consists of the following simple procedure: The pipe is placed in a vertical position in a suitable rack and the required amount of cement mortar is poured in at the top. A brass cone, which for the lack of a better name we call a "Torpedo" No. 1 is then pulled through the pipe from the bottom to the top. This No. 1 Torpedo is ¼ inch less in diameter than the diameter of the unlined pipe and has three fins soldered along its cylindrical portion. These fins are of such size as to just permit the torpedo to slide easily through the pipe. Their function is to keep the torpedo centered and insure a concenteric lining.

After Torpedo No. 1 has passed through the pipe it is followed by by Torpedo No. 2, which is ⅛ inch larger in diameter than No. 1. This torpedo carries no fins. Its function is to press against the walls of the pipe, the partially set lining of cement, and to enlarge the opening to the desired finished diameter, namely, ⅛ inch less than the original pipe diameter.

The mixture used is two parts by volume cement, one part sand and one part water. This has given us the most satisfactory results. The time interval between the passing of the two torpedos must be such that the lining has had an opportunity to set slightly. As a matter of fact, the controlling factor is the operators ability to pull the torpedo through the pipe.

The reasons for the various steps of the method adopted can probably be made clear by tracing the history of our experiments.

Our first attempt at cement lining galvanized pipe was to try to cement the pipe in a horizontal position. We used a neat mixture of "Louisville Cement," but we were unfortunate in all our attempts.

If the mixture was made of such a consistency as to allow the torpedo to be pulled through it would drop or slough off behind the torpedo and in some instances would entirely close the pipe. On the other hand, if the consistency was thickened to a point where this would not happen, the torpedo would get stuck in the setting cement before it it could be pulled through. This difficulty, coupled with the fact that it was a real sleight-of-hand performance getting the cement into the pipe, practically drove us to try the vertical position.

By this time, we were so positive that we could line pipe that we built an experiment tower that would hold 40 lengths of pipe, 20 on each side. Further experiment on this tower soon showed us that this "Louisville Cement" set too quickly and would not do. The cement was put in the pipe by a funnel that was welded to a pipe coupling which was screwed on the top of the pipe. The cement was poured into the funnel and rammed to the bottom with a small wood pole about the same length as the joint of pipe. The funnel arrangement is still in use but we have since abandoned the pole. Our next venture was the use of the neat "Portland Cement." The torpedo we used up until this time was a smooth brass cylinder, tapered on one end, and $\frac{1}{8}$ inch smaller in diameter than the inside diameter of the pipe being lined. This was designed to give $\frac{1}{16}$ of an inch layer of cement. We continued using this type for a short while, but the cement would slough off and the hole would not be concentric even when we could succeed in holding the cement in place.

This led to the two torpedo idea. The theory—which proved correct in practice—was, that the first torpedo would center the hole and distribute the cement and the second would press the wall tight and catch what cement might slough off behind the first one. By the time the second torpedo got through, the cement had set up enough so that it had very little tendency to fall off.

We were now able to line pipe quite successfully. The difficulty now was that the neat cement had not much body, was relatively soft, and was rather expensive. We then started adding fine sharp sand to build up the cement body. We finally arrived at the mixture mentioned above, which has proven highly satisfactory.

DISCUSSION

WM. W. BRUSH: Do you find that the water remains hard for a long time with a cement lined pipe?

MR. REYNOLDS: When the pipe is new, referring to a large cast-

iron pipe, we get a considerable hardening of the water at first, which gradually reduces. Although the greater part of our cement lined system is three years old, we notice a harder water at the end of the system, but it is not of a serious nature.

QUESTION: Have you attempted to use any cement that is especially resistant to solution by water?

MR. REYNOLDS: I imagine Louisville cement would be better than Portland cement from that standpoint.

MR. BRUSH: I understand the National Pipe people are using a cement that has about one-sixth of the solubility of Portland cement.

MR. REYNOLDS: That would be more important to us in a cast-iron system than in steel pipe.

MR. BRUSH: Have you tried anything for the purpose of reducing the hardness of the water?

MR. REYNOLDS: We have not.

MR. SKEETER: When you take up these old pipes do you have much salvage?

MR. REYNOLDS: The salvage is in subdivision property. When we take over these subdivisions we take up their pipes and get rid of them. All this pipe that we have been lining with cement is galvanized pipe. We have made a practice of cutting our cement lined pipe with a hacksaw, because in using a pipe cutter the lining breaks off and results in a bad joint, but the pipe we have been using recently cuts quite well.

MR. BRUSH: Do you do anything with the nipple?

MR. REYNOLDS: No, we do not, but I believe the National Pipe Company are now selling a cement lined fitting. On account of the fittings being larger in diameter than the rest of the pipe, the tuberculation will be not too serious for the length of time we expect to use the galvanized pipe.

MR. MCCALLUM (Ottawa): Do you use any other kind of pipe except galvanized iron?

MR. REYNOLDS: No. We put the pipe in larger than indicated conditions would warrant.

MR. BRUSH: Do I understand that your operators pull this "torpedo" through by simply raising it hand over hand?

MR. REYNOLDS: They have a pulley. We use cheap spare time labor on that work, and we have not developed a highly refined apparatus.

MR. GORE: Do I understand that the pipe is filled with cement?

MR. REYNOLDS: No, not solid cement, but we put the cement down so as to be sure that it reaches the bottom. Experienced operators know just how much is necessary, but operators who are not used to it will waste considerable mortar. The torpedo will not come through too fast.

MR. GORE: How do you cure the cement?

MR. REYNOLDS: We try not to use the pipe for a few weeks after it has been lined. We do not put water into it, and we find that it will stand pretty rough handling.

EXTENSION PROGRAM OF KANSAS CITY, KANSAS, WATER AND LIGHT PLANTS[1]

By Arthur L. Mullergren[2]

Kansas City, Kansas, holds a rather unusual position among cities of its size in the public ownership of both the water and electric utilities. While the public ownership of water plants is quite general among all classes of cities, few cities of like size have undertaken the development and operation of a complete electric and power service. Since the acquisition and operation of these important services, the city had enjoyed a very large growth in population, industries and commercial importance. This growth has been so rapid that the expansion of the city's water and electric utilities, necessary to keep pace with even increasing demands, has been a vital problem for a great many years. While a normal growth was anticipated, such as any utility in a growing community might expect, the expansion of these utilities to their present size and importance was not foreseen. Therefore, for a number of years additions and extensions were made to the existing facilities as the increasing demands made them necessary. These extensions were usually made under the insistent demand and pressing need for more and better service. As is usually the case under such conditions, the quickest and easiest method of meeting these demands was followed without a great deal of thought of the future.

Several years ago it became apparent that these plants had reached a stage in their development with regard capacity, economy of operation, and the growing needs of a large modern city, where it became necessary to work out and adopt a comprehensive scheme of development which would assure adequate service at minimum cost and at the same time be adaptable to the needs of the community for a number of years. The adaptation of the water plant and distribution system to a well worked out program is well under way at the present time. In the case of the electric light plant, the development of the

[1] Presented before the Missouri Valley Section meeting, October 3, 1928.

[2] Consulting Engineer, Kansas City, Mo.

expansion plan has been postponed from year to year, due to the difficulties usually encountered in financing a large municipal program.

THE WATER PLANT

The water plant was acquired by the city in 1909, and has been enlarged and extended to its present state of development. The last major construction was the new filter plant, which was placed in operation in June, 1927. The plant is located on the Missouri River, north of the city, and is operated in conjunction with the light plant, the latter furnishing steam and electric power for the operation of the pumps. The low lift pumping equipment consists of the following pumps: One, DeLaval single-stage 30 m.g.d. centrifugal pump driven by 600 H.P. motor; two units same as the above mentioned pumps, but temporarily fitted with 20 m.g.d. impellers; one Worthington single stage, 20 m.g.d. centrifugal pump driven by 350 H.P. motor; one DeLaval single stage, 15 m.g.d. centrifugal unit driven by 200 H.P. motor; one Holly vertical triple expansion, triplex single acting pumping unit. This last named unit is an obsolete type and is used only for stand-by service. Discharge lines from low lift pumps connect to the condensers of the power plant, furnishing cooling water before reaching the treating basins. Under normal operating conditions, the cooling water requirements of the condensers exceed the needs of the water department so that a part of the water is returned to the river after passing through the condensers.

The water is passed through sedimentation and coagulation basins of a total capacity of 36 m.g.d. The filter plant consists of 9 rapid sand filters of a rated capacity of $1\frac{1}{3}$ m.g.d. each, and the five new $2\frac{2}{3}$ m.g.d. filters, making a total filter capacity of 25 m.g.d.

The high service pumping equipment consists of one motor driven and three steam driven pumps as follows: one DeLaval two-stage 25 m.g.d. centrifugal pump driven by a 2000 H.P. synchronous motor; one Snow horizontal cross compound crank and flywheel, condensing, duplex pumping unit rated at 12 m.g.d.; one Allis Chalmers pumping unit, same as the above described Snow pump; one Worthington horizontal, tandem compound, condensing, duplex, direct acting unit, rated at 9 m.g.d. The latter pump is of an old obsolete type and is only used as a standby unit.

The distribution system is supplied by one 24- and one 30-inch line from the plant. A storage reservoir of 13 m.g.d. is provided in the Argentine district. A booster station with two 5 m.g.d. motor

driven centrifugal pumps operate automatically to improve the pressure to the higher sections of the Argentine and Rosedale districts.

The total annual pumpage for the past several years is about six billion gallons. The connection of a large consumer this year will bring the total pumpage to nearly seven billion gallons, representing an average daily output of 19 million gallon. The maximum daily rate is approximately 21 million gallons.

Major improvements contemplated

Three major improvements to the water plant and distribution system are under consideration at the present time, namely: new turbine driven pumping unit and boilers, new trunk main on 18th Street, and several stand pipes and booster pumps to supply outlying districts on high ground.

Under the present method of operation the 25 m.g.d. motor driven centrifugal pump is depended upon for most of the high service pumping and the two 12 m.g.d horizontal steam pumps are operated only during periods of adjustments and repair of the centrifugal pump. A new high service pump of 25 to 30 m.g.d. capacity is necessary to insure adequate high service pumping capacity, and provide ample protection in the case of a bad fire.

Recent years have brought about the development of large capacity steam turbine driven centrifugal pumping units, which under the new conditions of higher steam pressures and temperatures, have been able to equal and in some cases exceed the fuel economy of the old triple and quadruple expansion pumping engines. The centrifugal pump can be built in larger capacity than the old pumping engine and has a decided advantage in lower first cost and space requirements.

A steam turbine driven centrifugal pump unit of about 25 m.g.d. capacity operating against a total head of 325 feet, has been recommended and will be the next step in the development of the pumping station. The pump will probably be made up of two single stage, double suction, units, connected in series and mounted on a common shaft driven by a high speed condensing turbine by means of speed reduction gearing. The steam conditions under which the turbine will operate will be fixed by that selected for the new power plant boilers as this unit will receive steam from the power plant header. In case the pump is installed before the installation of the new boiler equipment provision will be made in the design of the turbine permit-

ting its operation at reduced steam pressure and temperature until such time as the new steam condition is made available.

The present trunk mains supply the main business and industrial centers as well as the Argentine reservoir. The mains planned for this extension would be a 30- or 36-inch line extending from the plant west to Eighteenth Street and south along Eighteenth Street to the vicinity of Osage Avenue, a distance of approximately five miles, with proper interconnections to the existing mains and the Argentine reservoir. This main would eliminate a large part of the friction lost in pumping to the Argentine reservoir and permit a more effective use of this storage reservoir.

There are several districts in the city which receive adequate pressure while the high service pumps are in operation, but receive insufficient gravity pressure from the Argentine reservoir. In order to protect these districts, two or three elevated storage tanks with automatic booster pumps are being considered. The hill section south of the Kaw River and a section in the northwest part of the city are being considered for the initial installations.

When these three improvements have been completed the growing needs of the city for water service can be met for a considerable term of years by minor extensions and improvements.

THE LIGHT PLANT

The present light plant is located adjacent to the water plant and is operated in conjunction with the same. The boiler plant consists of the following water tube boilers and underfeed stokers: Six 601 H.P. Sterling, with Westinghouse stokers, two 500 H.P. Murray with Jones stokers, two 465 H.P. Bonus with Jones stokers, one 350 H.P. Babcock and Wilcox with Jones stoker, four 300 H.P. Heine with Jones stokers and one 250 H.P. Heine with Jones stoker. The six Sterling and two Murray boilers are set in high settings and are depended upon for regular duty. The balance of the boilers are old units and are suitable only for emergency service. The boilers are served by turbine driven centrifugal boiler feed pumps and turbine driven forced draft fans. The boiler plant is operated at 175 pounds pressure and about 100 degrees Fahrenheit superheat.

The generating equipment includes the following 2400 volt, 3 phase turbo generators with surface condensers; two 12,500 Kva Westinghouse, one 5000 Kva Allis-Chalmers, two 3150 Kva Allis-Chalmers. Steam and motor driven exciter sets are provided and a step-up

transformer station for 2300 to 13,200 volt service. Several 2400 volt feeders to nearby districts connect direct to the feeder panels. However, the greater part of the energy is transformed to 13,200 volts and transmitted over three pole line feeders to sub-stations located near the center of the load. The voltage is transformed back to 2300 volts at the three substations and distribution feeders serve the respective territories at this voltage. The substations have been well located and the 13,200 volt feeders and 2300 volt distribution feeders seem adequate or capable of extension to meet the present and immediate future demands.

The need of additional boiler capacity has been pressing for several years. During the summer of 1925 the author was retained as consulting engineer to make a thorough survey and study of the existing plant and facilities and to determine the most feasible plan of development, taking into consideration the present as well as the ultimate needs of the city. Due to the need at that time of additional boiler capacity, the initial plan covered a new boiler installation consisting of two 1400 H.P. units with building space sufficient for two additional boilers, coal preparation and handling equipment and a steam header connecting with the existing steam header. However, before it was possible to determine the location and capacity of the boiler units it was necessary to work out a complete scheme of development, which resulted in the recommendation of a plan for a power plant having an ultimate capacity of 100,000 k.w. This plan provided for the proposed plant to be located so as to interfere as little as possible with the existing plant facilities and at the same time is arranged so that it would fit in with the present as well as the ultimate plant. In other words, it was necessary that the new and existing plants be operated as a unit for a time during this development. The ultimate plan provided for a new building just north of the present turbine room and taking up the full width between the property line and the filter plant. This plan required the relocation of the water pumps in the north end of the existing boiler room after the old boilers had been removed and the conversion of the present turbine room into a switch room.

The first step in the plan was the erection of the central section of the boiler room and the installation of two boilers. The second step required the installation of a new 25,000 Kva generating unit with necessary building and the installation of two additional boilers. The third step consisted of the re-building of the two old 12,500 Kva units

to operate under the new steam conditions chosen for the new plant, together with two boilers and the necessary additional building. This would give a station capable of carrying a peak load of 20,000 k.w. with a second unit in reserve and operated in conjunction with the remaining units of the existing plant, would be capable of taking a peak of 29,000 k.w. when the 25,000 Kva unit was down for repairs.

When the peak load has reached 29,000 k.w., the fourth step of the plan would be undertaken, involving the installation of a 37,500 Kva unit with boilers. After this installation the plant would be capable of carrying a load of 40,000 k.w. with the largest unit down. As the old boiler plant is uneconomical in the generation of steam due to low pressure and temperature, the old plant would be dismantled after the installation of this first 37,500 Kva unit. When the load has reached 40,000 k.w., the second 37,500 Kva unit is to be installed, bringing the total generating capacity to 100,000 k.w. and providing for an hourly peak of 70,000 k.w. when one of the largest units is down for repairs. The estimated peak is not expected to reach this maximum until about 1950, and a new plan will more than likely be adopted in order to be in keeping with the advances of power plant construction obtaining at that time.

Each year for the past few years has brought about new ideas in the generation and utilization of steam. This advance in methods, equipment and economies has been so rapid as to make some comparatively new plants obsolete. Equipment selected for the new plant will be designed for pressures and temperatures considerably higher than those in the present plant. A pressure of from 450 to 600 pounds with the steam superheated to a total temperature of around 700 degrees Fahrenheit is probable. Pulverized fuel equipment in place of the present stokers is being considered and the use of furnaces with the walls made up largely of water heating surface is probable. This type of boiler equipment is capable of operating at very high ratings. In some cases as high as 700 percent of normal boiler capacity has been obtained. A large number of important power plants have been giving satisfactory service for several years under the new conditions which proves that materials are capable of withstanding these high pressures and temperatures.

RAILWAY WATER TREATMENT PROGRESS[1]

By R. C. Bardwell[2]

Records indicate that the first concerted study for improvement of water quality used on American railroads was conducted by the American Master Mechanics Association, which was the forerunner of the present Mechanical Division of the American Railway Association. The study was started in 1870 and continued for three years with the resulting conclusion that the annual damage done to locomotive boilers by the average waters available was $750 per locomotive, made up of additional boiler repairs, $360, additional coal (at $2.50 per ton), $340, and additional boiler washing, $50. As an indication that these figures were not badly out of line, recent investigations by the Water Service Committee of the American Railway Engineering Association have shown that the present cost of damage caused by uncorrected poor quality waters will vary from $1,500 to $4,000 per locomotive per year which is comparable with the increase in cost of locomotives, material, and labor over the 1870 prices.

The boiler damage in the period of the American Master Mechanics Association of 1870 consisted principally of scale with resultant boiler leaking and short life of flues and fire box. The proper remedy was reported and recommended, but due to the greater attention being given to railroad expansion and less consideration to features involving operating economies, action was delayed and it was not until 1891 that the Union Pacific was reported to have built the first water treating plant used on any American railroad for the purpose of delivering water to roadside tanks fit for boiler use. Additional plants were installed on the Southern Pacific and in Ohio in 1896.

The results from these plants must have been satisfactory as the period beween 1900 and 1905 witnessed considerable activity in this field. The Water Service Committee report published in the Pro-

[1] Presented before the Boiler Feed Water Studies Committee Session, the Toronto Convention, June 25, 1929.

[2] Superintendent, Water Supply, Chesapeake and Ohio Railroad, Richmond, Va.

ceedings of the American Railway Engineering Association for the year 1905, called attention to the water treatment installations on the Atcheson, Topeka, and Santa Fe, the Chicago and Northwestern, the Chicago, Rock Island and Pacific, the Southern Pacific, the Union Pacific, and the Pittsburgh and Lake Erie Railroads. This development was largely on the western railroads where the water quality conditions are more severe and water impovement was somewhat of an operating necessity, the single eastern road being bothered with troubles incident to pollution of steams by acid coal mine drainage.

The period from 1906 to 1915 appears to have covered a decline in the interest shown in railway water supply in general, except for the study reported by the American Railway Engineering Association, Water Service Committee in 1911 showing that the average cost to the railway companies for each pound of adherent scaling matter going into the locomotive boilers amounted to 7 cents, which figure transposed to present day prices is 13 cents and still represents a fair estimate of the damage to be expected.

However, during this period there were but few railroads with definite water departments and the responsibility for carrying on such work was under supervision of officials who were primarily interested in other matters and the water treatment did not receive the attention and support which is necessary for continuously satisfactory results.

It is believed that credit for the greatest impetus which has been given Railway Water Treatment Progress was the classic demonstration of the possible economies to be secured, by C. H. Koyl on the Great Northern Railroad from 1912 to 1918. Under the efficient direction and supervision of Dr. Koyl, entire engine districts in the bad water territory were completely equipped with softening plants and his system of overtreatment and practically complete removal of objectionable scaling matter accomplished such economies and improvements in transportation that the attention of railway authorities was again directed to the possibilities of this work.

Progress has continued at an increasing rate. In 1910 there were about 100 complete lime-soda ash plants in operation for locomotive use and the amount of water softened annually was about 3 billion gallons. In 1920, the number of such plants had increased to about 400 with an annual treated water delivery of 14 billion gallons. At the present time, many of the large railroads have extended their softening plants to include a large percentage of the water used for

steam purposes, and it is reported that there are over 900 complete plants now in service treating about 50 billion gallons per year. In addition there are some 600 plants using soda ash or sodium aluminate only and treating 16 billion gallons annually; 300 wayside tank plants, mixing anti-scale compound with 13 billion gallons annually; forty zeolite plants softening 4 billion gallons annually; and about 15 billion gallons are treated per year with anti-scale compound in engine tanks or boilers. This indicates an annual total of 98 billion gallons of water now receiving correction on American railroads. As the entire amount of water used for steam consumption to haul the enormous tonnage of this country will approximate 350 billion gallons per year, only 28 percent is being given attention and there still remains much room for further progress in handling the remaining 72 percent.

The progress and development in type and plant construction has also accompanied the increase in number of plants and amount of water treated. The first plants constructed were of the types used at the time the process was invented by Dr. Clark in 1840 and Dr. Porter in 1847. Alternate tanks were filled, chemicals applied, stirred, and allowed to settle, the tanks being filled and used in rotation. This is called the intermittent system and is being used to some extent at this time due to simplicity, low maintenance and ready adaptability. About the year 1900, the continuous plant began to receive serious study. In this type the chemicals in predetermined ratio are mixed with the water as pumped, and the softened waters after suitable sedimentation period, assisted in some cases by filtration, are ready for use in boilers. The tank most favored is the cylindrical steel standpipe type of sufficiently large diameter to maintain the maximum vertical velocity below 8 feet per hour and with a downtake tube or reaction chamber of such size as to retain the mixture of water and chemicals for a period of not less than 30 and preferably 45 minutes, before the sedimentation starts. A number of good devices are available on the market which will proportion the chemicals to the water pumped with reasonable accuracy and a portion of the credit for progress in railway water treatment is due to the increased reliability and dependability of such devices which were developed with the demand.

Similar progress has been made in the results secured by boiler compound treatment. From haphazard rule-of-thumb methods of using uncertain mixtures exploited by smooth talking salesmen, good results are now being secured by coördinating the compound mixture

and treatment, at wayside stations as well as in boilers and engine tanks with requirements as developed by water analyses and inspection of boilers. Where competent service men work with the coöperation of the shop forces and engine crews, very creditable records have been made in many instances, and the cause for most failures can be traced either to lack of competent technical supervision, or to carelessness in carrying out instructions.

Possibly the latest development in railway water softening is the installation of zeolite softening plants with satisfactory results. This process was started in the west about five years ago after failures when used on high carbonate waters in Ohio. With better understanding of its limitations, success is expected and installations are again being made to some extent on eastern railroads.

The installation of plants using barium treatment has been very limited in railroad practice. There are only a few plants in the entire country, due largely to excessively high cost of suitable barium salts. Progress in this method will undoubtedly be delayed pending lower prices for the barium compounds.

The standard and usual method for complete water softening in railroad practice continues to be the use of lime and soda ash added to the water in predetermined amounts at wayside settling tanks with the object not only to soften the water, but also to remove the precipitated sludge with mud and other suspended matter so as to deliver the water to the boilers not only soft but clean. Common lime, usually hydrated and furnished in 50 pound paper sacks, and soda ash are used, for they are the lowest priced chemicals that can be obtained which will do the work efficiently and economically.

A marked improvement in treating plant results has been effected during the past four years with use of sodium-aluminate in conjunction with lime and soda ash. This chemical appears to have the power to remove the troublesome magnesium salts in addition to affording coagulation and hastening chemical reaction and sedimentation, giving a clearer water with less residual hardness. Better results and increased efficiency have resulted from its use.

Another marked development in railway water service progress is the recognition of the importance of adhering to a well regulated blowdown schedule. With this practice followed in line with carefully determined tests it is possible to keep the locomotive boilers clean and free from sediment, which affords economy not only in reduced boiler maintenance, but also in less time lost for washing out and increased availability of the power.

A contributing factor in improving the railroad water treating situation was the development of suitable rapid methods of water analyses which would be sufficiently accurate and dependable for control and check, as the long and tedious procedure outlined in the Standard Methods, while very fine for a large central laboratory or research department was not at all applicable for keeping in touch with the situation over thousands of miles of territory. With the simple and dependable titration tests using standard soap and acid solutions in which 1 cc. is equivalent to 1 mgm. of calcium carbonate, the procedure has been standardized and reliable comparative results are available.

The discussion of railroad water treatment progress would not be complete without calling attention to the long uninterrupted period of consistently fine results secured by W. A. Powers, now retired, but formerly Chief Chemist of the Atcheson, Topeka and Santa Fe. Starting with the early development of railroad water softening, he maintained the immense Santa Fe system at the forefront in this field and it still leads both in number of plants and in amount of water treated. The most recent extensive development is taking place on the Baltimore and Ohio under the direction of C. P. Van Gundy, Engineer of Tests, whose experience in railroad chemistry covers many years. Mention should also be made of the development work carried on during the early periods by G. M. Davidson, Chemist and Engineer of Tests for the Chicago and Northwestern, now retired. Credit should also be given Cass Kennicott for his interest and initiative in developing suitable proportioning equipment during the early periods. Many plants of his design are still in service.

Looking back over the progress in this field, it must necessarily be concluded that the success or failure is largely dependent upon the personnel. The basic principles are fundamentally correct and possible economies are always present, frequently in astonishingly large amount, as steam railroads use, both by volume and weight, more water than all other materials and supplies combined, and slight variation in quality may be reflected to a considerable extent in the aggregate. The range of the problem not only includes the chemical features, the design, installation, and operation of the plants, the coördination of the results with the work of engineering, maintenance, motive power, and operating departments, as well as the effect upon transportation and train movement. Where definite authority has been assigned along these lines with a competent per-

sonnel, the results have proven that this work is an important feature in economical railroad operation.

RESEARCH REQUIREMENTS

1. Scale formation and treatment

With reference to the progress toward solving problems connected with the deposition of scale and trouble from leaky boilers, the work to date seems to have been carried out in a fairly satisfactory manner and information is available which can be applied in a practical manner to take care of the ordinary case. However, additional knowledge regarding coagulation, precipitation, and sedimentation can be used to advantage particularly as to why increased agitation of the chemicals and water improve the results in some cases and act adversely in others. The relation of the hydrogen ion concentration, not only to the coagulation of turbid waters, but also to the deposition of protective film formation in the boilers is also a problem requiring additional study.

2. Foaming and priming

The present means of controlling foaming and priming in locomotive boilers is largely by rule-of-thumb methods involving either blow-downs to reduce concentration or by use of a castor oil anti-foaming compound to raise the permissible limit of alkali salt concentration. The fundamental factors involved are not thoroughly understood and study will be required before they can be brought under control. The work being done by Foulk at Ohio State University indicates that interesting information will be made availabe which will serve as a basis for better understanding of this phenomenon.

3. Pitting and corrosion

The many articles and speeches being made about pitting and corrosion conclusively demonstrate that even the best minds in the country are still at a disagreement regarding causes and cures, and that no generally acceptable understanding has been reached which can be used for effecting permanent relief. This is as true in railway service as it is in outside cases and only by intensive research can the problem be solved or the fundamental factors developed which may be applied with assurance of success.

It is hoped that facilities will soon be made available for carrying

out the extensive and important research studies in this connection under the direction of the Joint Committee on Boiler Feed Water Studies, as the railroad laboratories are so thoroughly engrossed with the day to day problems of actual operation that the intensive study required for such problems can only be carried on with great difficulty and the situation is not ordinarily conducive to the successful handling of this type of work.

ENGINEERING STUDIES OF MUNICIPAL ZEOLITE WATER SOFTENING[1]

By Harry N. Jenks[2]

Although the chemistry of zeolite water softening has been extensively described in current literature, yet comparatively little information is available, from the engineering point of view, on the practical use of zeolites in the softening of municipal supplies. The purpose of this paper is to present some of the important engineering considerations pertaining to this phase of water treatment, as suggested by the results of preliminary studies made on a practical-scale softening apparatus in the sanitary engineering laboratory of Iowa State College. These experiments dealt with the engineering factors only in broad outline; accordingly the following notes constitute something in the nature of a progress report, and refer in part to the studies that were made, and in part to those that doubtless should be made in connection with the problem of municipal zeolite water softening.

SUMMARY OF EXPERIMENTAL WORK

Description of apparatus

In the conventional rapid sand filter, the filtering action occurs chiefly by virtue of the contact between the water and the surface of the sand grains. A similar condition exists in the zeolite softening process. Since the water treatment unit under consideration partakes of the structural nature of the rapid sand filter, and of the functional nature of the ordinary water softener, it may well be designated as a "contact-softener," a name suggested by Chas. P. Hoover in his discussion of this paper.

The experimental contact-softener consisted of a reinforced concrete box 3 feet by 4 feet in plan and 4 feet 8 inches high, as shown

[1] Presented before the Water Purification Division, the San Francisco Convention, June 13, 1928. Revised January, 1930.

[2] Consulting Sanitary Engineer, Engineering Office of Clyde C. Kennedy, San Francisco, Calif.

in figure 1. Thus 12 square feet net filter area was provided, together with a height of 12 inches freeboard to the overflow weirs, when the box was filled with 30 inches of zeolite sand.

The box was designed primarily for studying the hydraulic efficiency and structural suitability of the asphalt-cemented gravel slab underdrain system that was made an integral part of the filter and occupied the bottom 8 inches of its depth. For this reason the size of the softener was such as to render impracticable at this time carrying the water softening studies as far as will later be done, especially with

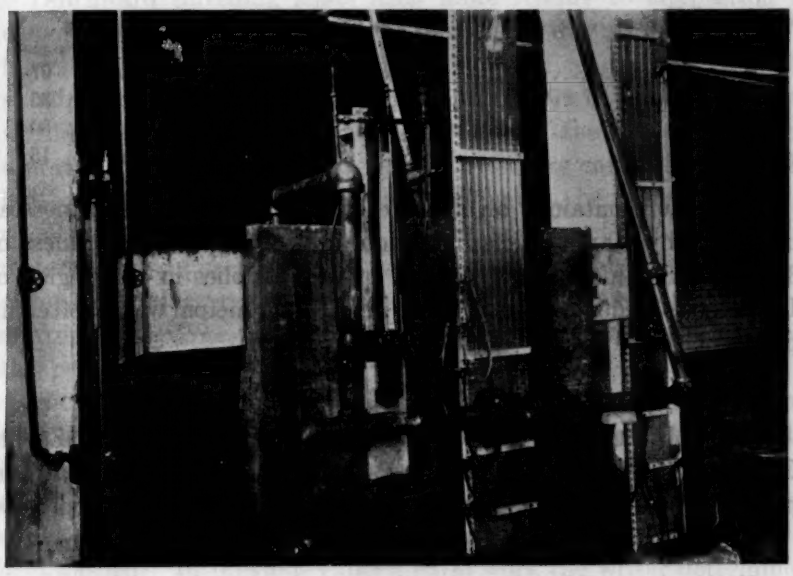


FIG. 1. VIEW OF EXPERIMENTAL CONTACT-SOFTENER

Tests made with greensand resting on asphalt-cemented gravel underdrain system. Softener equipped for hydraulic measurements.

reference to rates of flow and total capacity between regenerations. This can best be accomplished in a much smaller contact-softener unit, of perhaps 1 square foot area.

Complete data were not secured concerning losses of head within the system, but what measurements were made showed that the general behavior of the unit from the hydraulic viewpoint was quite similar to that of a rapid sand filter. Loss of head through the asphalt-cemented gravel slab corresponded to that determined in detail for a similar porous slab underdrain system using Portland

cement, studied by the writer at Sacramento, and described in THE JOURNAL (Vol. 16, No. 5, November, 1926). Suitable interconnections of the piping permitted softening either up or down. Downward salting was adopted, and upward washing followed by downward draining.

Water supply

The water used in the experiments was that supplied by the College wells, having first been treated in the institution's iron removal plant. The significant constituents of the water in relation to these studies were as follows:

	p.p.m.
Calcium	97
Magnesium	35
Sulphate	80
Chloride	15

The water contained an average of 388 p.p.m. total hardness as measured by standard soap solution, and a temporary hardness of 315 p.p.m. This water is typical of well supplies in this region of Iowa and is evidence in itself of the need for municipal water softening plants.

The zeolite mineral

The zeolite used in the tests was kindly supplied by the Zeolite Chemical Co. of New York at a special price for experimental purposes. The mineral was a green sand having the following properties:

Effective size	0.23 mm.
Uniformity coefficient	1.91
Weight per cubic foot (air dried)	86 pounds
Total exchange capacity per cubic foot	3970 grains

It is readily understood that quantitative data obtained through the use of any one zeolite are not directly applicable to other types of minerals. Results so obtained give merely an indication of the influence of various design factors and methods of operation to be expected from the zeolite process in general.

Water softening capacity studies

Observations on upward and downward softening. The economic softening capacity of a zeolite, as measured by the total grains of

hardness removed between regenerations, is dependent upon a number of factors, one of the most important of which is the effective contact of the water with the particles of the mineral. This, in effect, defines the softening efficiency of the zeolite. One of the most important matters to determine in this connection is the relative efficiency of upward and downward softening. It is generally understood that this is a mooted question among designers of commercial water softeners. Accordingly one should go into this question rather thoroughly in connection with any proposed engineering design.

Downward softening lends itself more readily to adaptation to conventional filter design because that is the way in which water is filtered. Also, better distribution downward is possible from the standpoint of the more nearly stable hydraulic balance that exists within the sand bed than when the course of the water is directed upwards. On the other hand, upward softening entails considerably less loss of head, at least for the higher rates, because the sand is wholly or partly in suspension. In this case, compacting of the mineral such as occurs in downward softening is obviated. In any event a satisfactory underdrain-distribution system is required, a matter that will be discussed somewhat in detail at a later point in this paper.

The chief cause of impaired availability of the water softening capacity of a given sand is what is known as "channeling." With low rates of softening, the question of channeling on upward flow should receive particular attention. As regards this difficulty, the situation is similar to that which obtains when a rapid sand filter is backwashed. In previous experimental work the writer determined that even with the best distribution means possible, a uniform backwash of a filter can scarcely be obtained under 12 inches vertical rise per minute, at which point the sand bed is practically completely in suspension. Accordingly, if a uniform distribution of water throughout the zeolite bed is to be obtained, it appears probable that the critical rate of softening to avoid channeling on upward flow will be about 7 gallons per square foot per minute.

In contrast to upward flow, if downward softening is proposed, the question of excessive loss of head, particularly with the deep zeolite beds that are to be recommended in practice, should be investigated. The thought suggests itself that, in view of the opposing characteristics of upward and downward softening, an engineering design might provide means whereby downward softening could be effected

during periods of low consumptions, while upward softening might be practiced during peak loads. If the contact-softener is to be operated at a constant rate, however, it would appear advisable to restrict the sand area and employ upward flow through a deep bed, or else to use a bed of relatively shallow depth and correspondingly greater area, and soften the water downward through the mineral.

The statement previously made in effect that, for a given rate of flow, channeling occurred to a less extent during downward softening, was evidenced by the analyses of the softened water in each case. At the low rates, completely softened water was not obtained when softening upward, but when the direction of flow was reversed, for the same rates, soft water was obtained. Furthermore, when a deep bed was substituted for a shallow one, the advantage of downward softening was increased until the critical rate for upward softening was reached, when upward softening had the advantage of much less loss of head.

The disposition of the mineral bed within the contact-softener. The question suggests itself as to the range through which the area and depth factors of the sand bed might reasonably be varied to suit different operating conditions, or conditions of design. It was found that variations in the relation between depth and area for a given volume of mineral had no influence on capacity except insofar as the difficulty due to channeling became more or less pronounced as a result of the particular disposition of the sand adopted. Again, in reference to softening rates, it was found that regardless of the depth of sand bed, zero hardness water could be obtained for any rate below a critical value which corresponded to a contact period of about 6 minutes. This period was arbitrarily computed as the flow in cubic feet per minute, divided by the cubic feet of mineral in the softener. In general it was observed that, in spite of the assumption that is frequently made to the effect that the base exchange occurring in zeolite mineral is practically instantaneous, a rather definite time element must be present to secure water of zero hardness. This time factor is a function of the volume of zeolite and the rate of softening which, taken together, result in a definite period of contact with the mineral.

Regeneration and wash water studies

Methods of introducing salt solution. Observations showed that this question warrants much further study, and there seems to be good

reason to believe that considerable improvement may be made over the usual methods of introducing the salt solution when regenerating a contact-softener. In beds of large size such as would be encountered in municipal plants, it is of more importance than usual to be able fully to utilize the salt solution. One source of waste is the lack of contact of the brine with the zeolite when allowed to pass through the bed at too rapid a rate. On the other hand, if the salt is fed through at as low a rate as may be required, considerable time may be lost in regeneration, when measured by the number of hours during which the contact-softener would be out of service. Accordingly, it would appear reasonable to assume that if the brine were recirculated through the mineral bed, the required period of contact could be secured within greatly reduced time. A means of accomplishing this and observations on the results of such a procedure will be carried out by the writer in connection with his design of a municipal water softening plant at the present time.

Influences of design on wash water requirements. It has been shown that the amount of wash water needed as well as the salt consumption, is a function of the softening capacity and other characteristics of the mineral in question. Aside from the physical and chemical factors entering into this situation, the design of the softener structure itself, as well as the method of washing, must have an important bearing on the amount of wash water needed.

As regards the structural element, perhaps the most important way by which the amount of wash water may be conserved is to limit as much as possible the waste space underneath the sand bed which must be filled with the water used for washing purposes before the real work of washing can begin, regardless of whether such washing is done, in the first place to loosen up the zeolite bed prior to salting, or to wash the bed free from the brine so introduced. The filter bottom studied experimentally and proposed as an underdrain-distribution system for use in a contact-softener, accomplishes to a satisfactory degree the purpose of eliminating a large part of the waste space incidental to the use of the ordinary graded gravel bed. Because of the possibility of limiting to within 8 inches the thickness of the cemented gravel slab involved in this underdrain system, in contrast to 18–22 inches of graded gravel, it possesses to a comparable degree the advantage claimed for one type of commercial softener underdrain wherein the sand rests directly on the bottom of the softener casing.

Another feature of engineering design that should be included to permit the economical use of wash water in operation is a means whereby washing may be accomplished downwards for removing the residual brine before placing the contact-softener in operation again after regeneration. This method of washing is in conformity with well-recognized laboratory technic in connection with the washing out of precipitates. Here a stream of water is directed against the sides of the funnel in which the precipitate may have been filtered out, and is worked down from the top towards the bottom. This flushing action carries the material in solution always in the same direction and without mixing with previously washed material. Moreover, in a large-sized contact-softener, washing upward would, in any event, involve undue waste of water in simply filling the space between the sand bed and the wash water gutters above the bed.

THE DESIGN OF THE UNDERDRAIN-DISTRIBUTION SYSTEM

In the operation of a full-scale contact-softener, the design of the underdrain-distribution system assumes considerably greater importance than in the case of smaller units. The design of this feature has been, for some time past, a bone of contention among manufacturers of water softening equipment, and has led to complications due to patent litigation.

It may be recalled that the writer, while in charge of the operation of the Sacramento pumping and filtration works, developed a cemented graval slab—vitrified clay pipe distribution system for rapid sand filters, which by actual test in a 4 m.g.d. filter unit, proved eminently satisfactory from every standpoint but that of durability. To correct this, the writer continued his studies of this type of filter bottom at Iowa State College, working with an asphalt-cemented gravel slab which gave excellent results.

Extensive and rigorous tests made on specimens of this slab showed that it is practically indestructible through chemical disintegration. The asphalt employed was obtained from the Standard Oil Co. of California. The specification called for Petrolastic asphalt, Grade X; penetration 5–7; and melting point approximately 200 deg. Fahr. It was considered that because of its durability, a porous slab bound together with this material should give satisfactory results when substituted for the porous slab previously studied, in which Portland cement had been used, and had subsequently disin-

tegrated. Such a slab was therefore installed in the experimental contact-softener used in the present studies. Previous to this, small cylinders of the porous medium were made in the laboratory, using various sizes and proportions of screened pea gravel and Petrolastic asphalt. The final proportions adopted were:

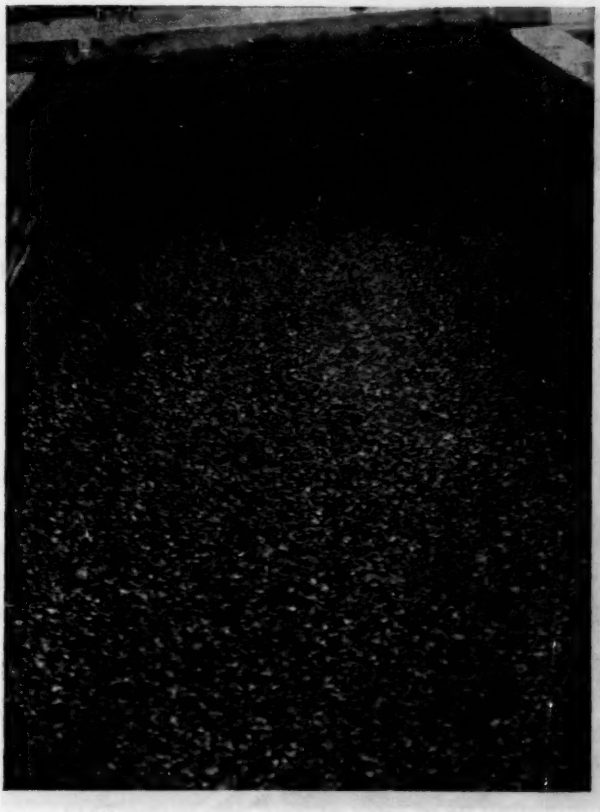


FIG. 2. POROUS GRAVEL UNDERDRAIN-DISTRIBUTION SYSTEM

An 8-inch slab of graded gravel bound by air-blown asphalt encasing the perforated pipe underdrains, and forming an integral part of the bottom of the contact-softener.

	Parts by weight
Gravel passing ½-inch screen and retained on ¼-inch screen	5
Gravel passing ¼-inch screen and retained on ⅛-inch screen	5
Petrolastic asphalt	1

This mixture gave satisfactory results as judged by reasonably low

loss of head and prevention of the passage of the zeolite mineral grains through the slab into the underdrain system. It may be mentioned in this connection that the zeolite sand rests directly on the 8-inch porous slab without the intervention of any loose gravel or coarse sand barrier. Figure 2 is a photograph of the asphalt-

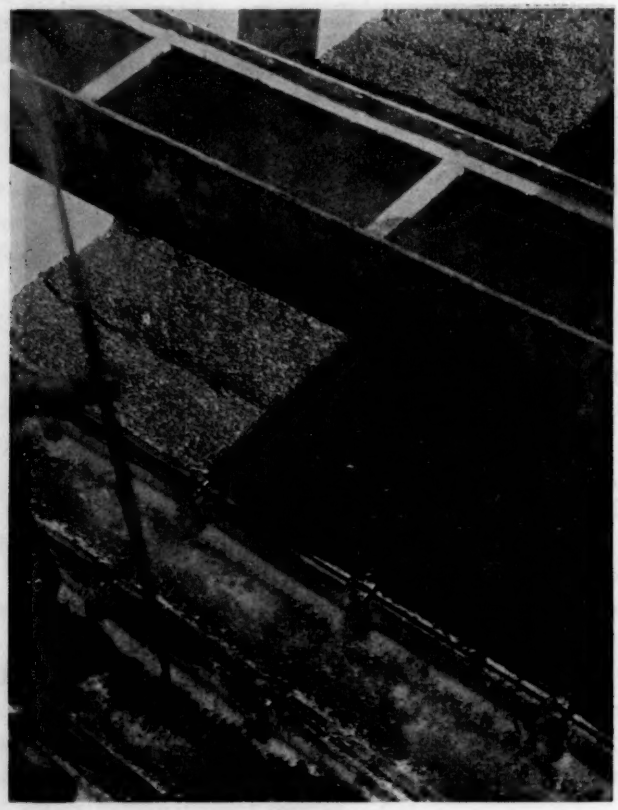


FIG. 3. PLACING AN ASPHALT-CEMENTED GRAVEL UNDERDRAIN SLAB IN A 4 M.G.D. FILTER

cemented medium as used in the contact-softener. The practicability of similar construction on a large scale has been demonstrated in a full-sized filter unit where an asphalt-cemented gravel slab was laid, as indicated in figure 3. On account of the considerably decreased mechanical strength of this slab as compared with that in which Portland cement is used, it would probably not be advisable to

employ perforated vitrified clay pipe as was done in the latter design. Instead, the usual perforated metal pipe should be used, encased within the slab which, in turn, bonds satisfactorily with the floor of the contact-softener and becomes an integral part of the structure.

ACKNOWLEDGMENTS

It is with pleasure that the writer acknowledges the work done by Geo. W. Burke, Chemical Engineer, Engineering Experiment Station, who conducted the experiments as a part of his graduate work in sanitary engineering at Iowa State College, under the writer's direction. Credit should be given Mark E. Driftmier and Chas. P. Rose, senior students in civil engineering who assisted in the experimental work and recording of data. The writer also wishes to acknowledge the kindness of Prof. Almon H. Fuller, Head of the Department of Civil Engineering, for his helpful coöperation at all times.

DISCUSSION

GEO. W. BURKE:[3] *Durability of asphalt-cemented gravel slab.* In conjunction with the studies reported in Prof. Jenks' paper, the writer undertook the testing of the asphalt-cemented gravel mixture mentioned in the paper. Pieces were exposed to the action of water containing relatively high amounts of ammonia, nitrites, nitrates, sulphates and chlorides for a period of six weeks. The solutions were renewed every second day and saved for analysis. At the end of the test no apparent action had taken place, which would indicate that the bitumen had created a protective coating, rendering the slab as a whole inert in water containing typical minerals. Accordingly there is good reason to believe that an asphalt-cemented gravel slab may be used in an underdrain-distribution system for a contact-softener. As proposed by Prof. Jenks, freedom from disintegration of the porous medium seems definitely assured.

Although, as compared with a slab in which Portland cement is used, there is a slight disadvantage in having to handle and place the asphalt-cemented gravel hot, yet it is thoroughly practicable to do so, as proved on a full scale test with a 4 m.g.d. filter unit some time ago.

[3] Chemical Engineer, Engineering Experiment Station, Iowa State College, Ames, Iowa.

The grade of asphalt to be employed contains no phenol compounds and its use is entirely without objectionable features from the standpoint of its effect on the quality of the filter or softener effluent.

Apparatus for routine tests in water softening plants. It may be of interest to describe at this point a simple piece of apparatus for testing the condition of the zeolite in water softening plants, as regards total capacity, its capacity at any given time, and the relative efficiency of softening on a large scale. As shown in figure 4, the apparatus consists essentially of a container, of perhaps 5-gallons capacity; a glass tube to hold the zeolite, about 2 inches diameter, and fitted with rubber stoppers and tubing as illustrated; and a graduated container to catch the softened water.

A convenient amount of zeolite to work upon would be about one pound, which is placed in the glass tube. The latter is fitted with fine copper gauze or graded gravel to hold it in place. The hard water is siphoned from the container above, the flow being regulated by the stop cocks or valves V_1 and V_2, and the soft water is collected in the graduated jug. With this simple arrangement, it is possible to study the total capacity of the mineral, rates of flow, salting and washing. It would also prove valuable to ascertain the extent to which a mineral had been revivified at any particular time.

For example, let us suppose that in municipal use, the total capacity obtained by use of green sand amounted to 1,500 grains per cubic foot. It is known that this is about one-half what it should give; therefore, it is desirable to know whether the method of salting has completely regenerated the mineral. This can easily be determined by taking some of the freshly salted mineral from the plant and determining its total capacity, using the equipment described. If the capacity obtained under such ideal conditions is the same as that on the plant scale, we know that the method of salting is inadequate to put the mineral in its best condition. Otherwise, we know that the mineral is completely regenerated, but that impaired efficiency is due to channeling or some mechanical difficulty in the practical operation of the contact-softener.

Effect of zeolite on concrete. As Mr. Jenks has suggested, the possibility of the zeolite attacking the concrete should be taken into account. The unprotected surfaces of the concrete structure comprising the contact-softener would be in direct contact with the zeolite bed. This being the case, we should expect the following

reactions to take place, perhaps slowly but to an extent that in the course of time, difficulty might be experienced,

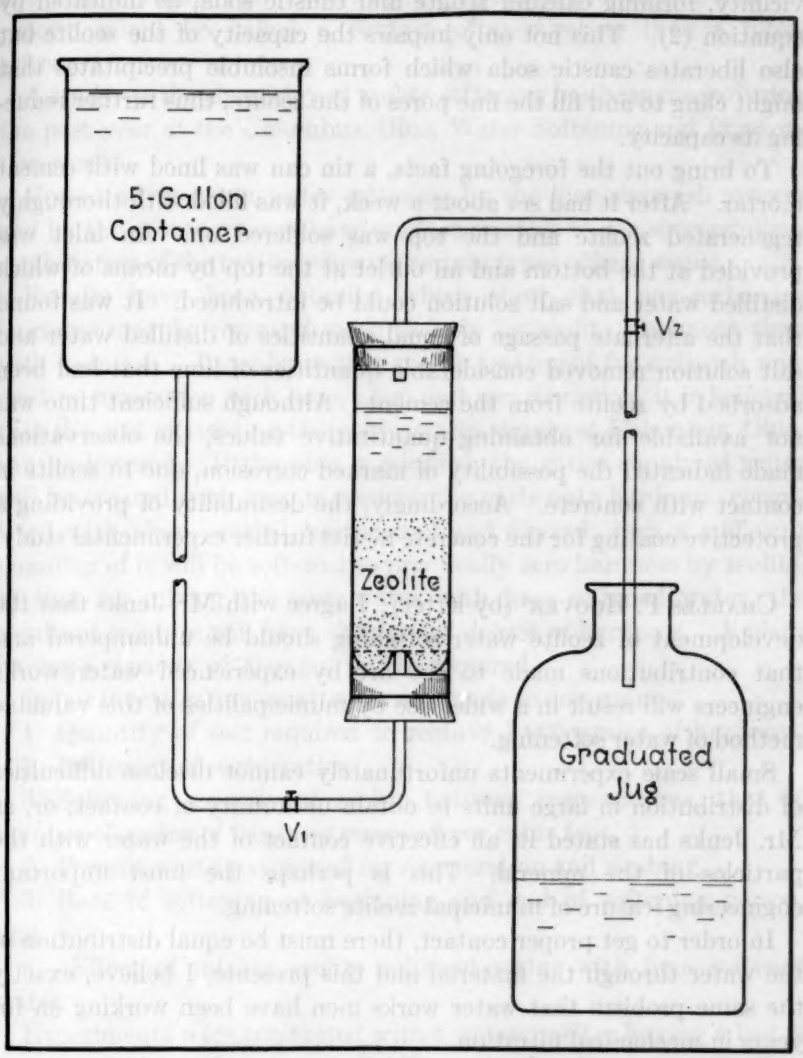


FIG. 4. LABORATORY APPARATUS FOR ROUTINE DETERMINATIONS OF ZEOLITE CAPACITY

(1) $$\text{Cement} + H_2O = Ca(OH)_2$$

(2) $$Ca(OH)_2 + Na_2Ze = CaZe + 2\,NaOH$$

(3) $$CaZe + 2NaCl = Na_2Ze + CaCl_2$$

Reaction (1) represents the action of water on the cement of the concrete. The lime set free reacts with the zeolite in its immediate vicinity, forming calcium zeolite and caustic soda, as indicated by equation (2). This not only impairs the capacity of the zeolite but also liberates caustic soda which forms insoluble precipitates that might cling to and fill the fine pores of the zeolite, thus further reducing its capacity.

To bring out the foregoing facts, a tin can was lined with cement mortar. After it had set about a week, it was filled with thoroughly regenerated zeolite and the top was soldered on. An inlet was provided at the bottom and an outlet at the top by means of which distilled water and salt solution could be introduced. It was found that the alternate passage of equal quantities of distilled water and salt solution removed considerable quantities of lime that had been adsorbed by zeolite from the cement. Although sufficient time was not available for obtaining quantitative values, the observations made indicated the possibility of marked corrosion, due to zeolite in contact with concrete. Accordingly, the desirability of providing a protective coating for the concrete merits further experimental study.

CHARLES P. HOOVER[4] (by letter): I agree with Mr. Jenks that the development of zeolite water softening should be unhampered and that contributions made to the art by experienced water works engineers will result in a wider use by municipalities of this valuable method of water softening.

Small scale experiments unfortunately cannot disclose difficulties of distribution in large units to obtain uniformity of contact, or, as Mr. Jenks has stated it, an effective contact of the water with the particles of the mineral. This is perhaps the most important engineering feature of municipal zeolite softening.

In order to get proper contact, there must be equal distribution of the water through the material and this presents, I believe, exactly the same problem that water works men have been working on for years in mechanical filtration.

Mr. Jenks' comprehensive studies on filter operation at Sacramento and his intimate knowledge of the many problems involved in filtration, make his observations and contributions on this subject valuable.

[4] Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio.

As contact of the water with the mineral is the important factor, and because the zeolite bed does not function as a filter in that it does not filter anything out of the water, I should like to suggest that the process might be called a contact-softener rather than a filter-softener.

A study on the chemistry of zeolite softening has been made during the past year at the Columbus, Ohio, Water Softening and Purification works.

Recent advances in water softening by the lime soda-ash process and by the zeolite process have made it possible to use successfully a combination of the two in softening certain types of hard water.

Results have been obtained which show that non-carbonate hardness may be removed more cheaply by zeolite treatment than with soda-ash. By substituting zeolite treatment for soda-ash now used in connection with lime, alum and recarbonation, it is believed that the cost of treating the public water supply of Columbus, Ohio, can be lowered. If the plan is adopted, the entire supply of water will be treated with lime to remove the carbonate hardness, coagulated with alum, settled, carbonated and filtered; then a sufficient quantity of it will be softened to practically zero hardness by zeolite, so that by mixing the zero water with lime softened water, the resultant mixture will have the desired degree of hardness. A plant having a capacity of 20 m.g.d. will be required.

In our investigation an attempt was made to determine:

1. Quantity of salt required to remove 1,000 grains of hardness;
2. Efficiency of regeneration;
3. Softening capacity of zeolite between regenerations; that is, number of grains of hardness removed per cubic foot.
4. Percent waste water used for regeneration and washing.
5. Rate of softening at beginning and end of softening period; and
6. Effect of mixing zeolite softened water with lime softened water.

Experiments were conducted with a pressure filter having a bed of greensand 34.9 inches deep and 1.72 square feet in area, and with a gravity filter having a bed of a gel type exchange silicate 66 inches deep and 2 square feet in area.

Our work has not been completed but the results so far, in a general way, show:

1. That the capacity of zeolites for removing hardness decreases as the quantity of salt used for regeneration is decreased.

2. That greensand has a softening capacity of 2500 grains of hardness per cubic foot between regenerations when 0.35 pound of salt is used per 1,000 grains of hardness removed; and,

3. That crystalite has a softening capacity of 5,000 grains of hardness per cubic foot when 0.35 pound of salt is used for each 1,000 grains of hardness removed.

RECREATIONAL USE OF RESERVOIRS[1]

By Carl Wilson[2]

Among the numerous phases of sanitation in connection with water supplies the question of recreational use of reservoirs impounding water intended for domestic consumption is one of perennial recurrence, seemingly incapable of final solution, at least for certain social elements. Hunters and fishermen are always seeking to have closed lakes opened and one cannot blame them, for the temptation to fish where bass are plentiful, or to shoot into flocks of tame ducks must be great indeed. Sportsmen are voters, and we may need their votes to carry necessary bonds, so a desire to make friends for the Department makes us anxious to please the sportsman. But not all voters are hunters or fishermen, in fact, at least 75 percent of them are not, and we must also consider the wishes of those who do not desire recreational privileges.

My own attitude toward the subject is naturally that of a waterworks man, so it may easily happen that I have overlooked some points which could be urged against my arguments. For the benefit of those who may not agree with me, let me make it clear that I am here expressing my own personal views in the hope that you will freely criticize them. My desire, and the aim of the Department I have the honor to represent, is to do all that should be done to protect domestic waters and to create public confidence in the quality, both hygienic and aesthetic, of the public supply. In the discharge of any public trust it is often necessary to limit the privileges of a few for the benefit of the many, but although such a course is unavoidable, it should not be carried further than expediency requires. Moreover, it must be remembered that circumstances alter cases, and in the preparation of this paper I have had uppermost in consideration the Los Angeles system as it is at present constituted and operated. On other systems, where conditions are different, perhaps greater freedom might properly be permitted.

[1] Presented before the California Section meeting, October 24, 1929.

[2] Biologist, Department of Water and Power, Los Angeles, Calif.

First of all, as waterworks men and public officials, we are pledged to protect our consumers and to serve them with water which is not only safe, but which is made appetizing to thinking people by a history of clean antecedents all the way from cloud to kitchen tap. Can we afford to ignore this obligation in order to gratify the selfish instincts of a small proportion of the population? The demand to open our lakes does not proceed from a real necessity which must be satisfied—it is rather a luxury, to be indulged as becomes a luxury, certainly not at the expense of others.

We are told by those who advocate recreational use that fees can be imposed for the privileges granted, and the money so raised employed in police measures to prevent pollution of the water. Insofar as the majority of hunters and fishers are concerned the writer likes to believe such measures would be completely effective, but he has had too much experience with self-styled sportsmen to think we can depend upon patrolmen for the high degree of protection we require, and this statement is not to be considered in any degree as impeaching the integrity of these guardians of public safety. Too many of our people are apparently accustomed to regard lightly infractions of the laws, all the way from breaking traffic and prohibition laws, to the taking of human life. It is too much to believe they will exhibit a special veneration for sanitary regulations. Ardent fishermen or hunters remain on a reservoir all day, and devotion to the task in hand often causes them to sacrifice sanitary obligations for convenience. Evidence of such laxness can generally be found along the shore line of any reservoir which is open to public use, especially about sheltered coves, or among shrubbery. This is true even where all proper facilities have been provided and where the patrol system would seem to be adequate.

Sanitary engineers tell us it is not only possible, but practicable, to convert the sewage of a city into pure and safe drinking water. Under the stress of circumstance this is already being done, while such procedure will probably become commonplace in the future, yet the thought of drinking reclaimed sewage is repugnant to most people. They want their drinking water kept clean all the time. It is true that purification methods have been so developed that it is possible to convert a grossly polluted river water into a safe supply for human consumption, but to accomplish it, the works must be carefully designed and built and constantly watched by highly intelligent and thoroughly trained operators. Even then we find only too frequently

that an outbreak of disease occurs through failure of some unit in the process in an unexpected manner. Where only a grossly polluted supply is available reliance must be placed upon purification, but in Southern California where our raw waters are exceptionally pure, is it not better to maintain their purity than to run the risk of polluting them through human contact?

A committee on "Sanitary Conservation of Streams," reporting to the Eighth Annual Conference of State Sanitary Engineers at Chicago states: "Strenuous efforts must be made to preserve the cleanliness of streams now in that wholesome condition."

The same report, when discussing the order of precedence of use of water resources, states:

"There can be no question that the use of water resources as the source of public water supplies is the first and highest use." Other uses, in order of precedence as set forth by this Committee are, sewage disposal, navigation, manufacturing, industry, power, irrigation, agriculture, fishing or recreation, as may be dictated by local circumstances. Recreational use seems to be regarded as of least importance. Is it wise to wilfully and knowingly run the chance of adding pollution of the most dangerous type to our water just because we think we can take it out? The writer does not believe such practice can be justified by any argument, especially where, as is often the case, the protective works are not complete, some step in the possible defenses having been omitted, as where chlorination is not supported by filtration or where filtration is practiced without disinfection. We cannot afford to take chances. All of us have had experience with waters which could not be successfully chlorinated without filtration, and everybody has seen the best filters fail to deliver a bacterially satisfactory effluent. In such cases we have much less to fear if we know our raw water has received little pollution. The less intimately such water may have been associated with human beings the greater our safety.

Behind the questions of technology, and perhaps of greater effect upon the public mind, is what may be described as the aesthetic reputation of our water. Most people are fastidious in matters pertaining to food, and the present world wide campaign to popularize knowledge in sanitary and hygienic matters is making them more exacting in this respect. Can we afford to ignore the demand of particular people that the public water supply shall not only be safe, but surrounded by such a clean and inviting environment as to create the

belief that it is wholesome and appetizing. Uncertainty as to conditions surrounding catchment areas and impounding basins, inspired and promoted by irresponsible salesmen, perhaps more than any other one thing, is the cause of bottled water sales in Los Angeles amounting to over two million dollars annually, while in Chicago, according to official reports, the figure is over six times as great. If consumers realized that no stone was left unturned in the effort to prevent pollution of the supply, as well as to remove such slight adventitious pollution as cannot be avoided, the saving to the community through reduction in the use of bottled waters would of itself justify the prohibition policy.

For the last eight years Los Angeles has prohibited recreational use of her reservoirs, and we believe the results attained prove the wisdom of our action. Filtration is not practiced, reliance being placed upon natural purification during storage, supported by chlorination. Of course, natural purification in an impounding reservoir is not compatible with recreational use, for it demands at least thirty days storage amid surroundings where re-pollution cannot take place. We depend upon and benefit through such natural processes to some degree, even in our terminal reservoirs, all of which store water for significant periods, and we cannot afford to sacrifice this advantage, which is really our margin of safety. Without filtration we have an enviable record for a safe water supply—not a single case of typhoid has been ascribed to our water since it has been municipally owned, a period of 27 years. Would our record have been as good had we permitted recreational use of our lakes? Perhaps, but the chance is great that the story would have had a different ending.

The proposal is frequently made that remote reservoirs might be thrown open to public use, leaving those nearer the point of consumption completely protected. Under some circumstances it might be proper to adopt such a policy, but the Los Angeles system does not lend itself to such a compromise. Our Haiwee reservoir is two hundred miles away from the city, in the midst of a practically desert region, but it is, biologically speaking, the key to our system. For more than a hundred miles to the north and west the Sierras send their creeks to feed Haiwee, and natural purification processes in this unique reservoir are depended upon to remove all pollution which may have occurred upon the catchment area, 3300 square miles in extent. This immense drainage basin is one of California's greatest playgrounds, and no restriction of its use is required or contemplated.

The public may hunt, fish, camp and otherwise enjoy this wonderland to the utmost, and Haiwee reservoir will function as a natural barrier to prevent the ill effects of intimate human association with the lakes and creeks from going beyond. But this will be true only if we prevent all pollution of the water in the reservoir. There must be an unbroken period of not less than thirty days during which natural purification can proceed to completion. Hence we feel we must also deny recreational use even on our most remote lakes.

During the course of talks to clubs and schools in Los Angeles the writer has frequently put the question as to whether those present preferred recreational use of our reservoirs, and the response has always been overwhelmingly in favor of prohibition. Frankly, I believe this to be a true reflection of public preference in the matter and it has influenced, at least in part, our policy of restriction. Certainly those officials who are held personally responsible for the protection of over a million and a quarter of human lives against the ravages of water-borne disease are not anxious to wilfully incur any risk, but must always err, if they err at all, upon the side of safety. We must be too strict rather than too lax, and it seems to me that we can conscientiously do nothing less than prohibit recreational use.

SOME UNUSUAL FEATURES IN THE DESIGN OF THE NEW WATER FILTRATION PLANT AT NIAGARA FALLS[1]

By Frederick A. Dallyn[2]

As preamble to this paper, which your Secretary invited in order to promote a general discussion of filtration practice, I must state that the plant to which my remarks relate has not as yet been built. The design has been complete for something more than a year, and tenders were invited for the building in the spring of this year; but owing to misunderstandings and political and other controversies, the work has not yet gotten under way.

In considering the unusual features of any water filtration plant, one most naturally starts with a clear understanding of the problem confronting the designing engineer. At Niagara Falls we have a Great Lakes water, taken from one of the connecting rivers at a point of high velocity, a water subject to some pollution, never very intense, and subject to turbidities which might be common also to such plants as Cleveland, Erie and Buffalo.

Lake Erie is a relatively shallow lake and storms promote a continuing turbidity, which sometimes exists for a week at a stretch. Ordinarily the water is fairly clear, possesses sufficient alkalinity to react with the aluminum salts without occasioning any aftermath of red water difficulties. The velocity of the river suggests that some difficulty might be encountered from frazil ice.

The site selected for the location of the plant was a point on Dufferin Island, where the ground elevation was some fourteen to fifteen feet below the mean elevation water level of the forebay of the Ontario Power Company. The elevation of the rock formation which forms the base of the reservoir was discovered some fourteen feet below ground elevation—i.e., about the ideal position for foundations. The site itself is part of the Niagara Falls Park system, and is heavily covered with vegetation, but accessible by road and by electric railway. The size of the plant, approximately 5,500 cubic yards of concrete, suggested that a central mixing plant would be an economi-

[1] Presented before the Toronto Convention, June 26, 1929.

[2] Consulting Engineer, Toronto, Can.

cal arrangement, and the elevation of the approach suggested that material brought in on the electric railway could be dropped into bins and mixers without secondary handling. By an understanding with the park, it was agreed to limit the destruction of trees to an area 75 feet around the limits of the proposed works. The problem of the contractor was to utilitize this ground to such advantage as to permit him to carry on the works expeditiously without any further destruction of vegetation.

The contractors bidding on the work saw no particular difficulty in the arrangement, except that, if the electric railway was not utilized, there might be some embarrassment experienced, owing to the Park Superintendent limiting loading capacity of trucks and vehicles for the purpose of preserving and maintaining during the tourist season, the river boulevard property, which also serves as approach to the plant.

The site naturally suggested a gravity plant with the high duty pumps arranged so as to draw directly from the level of the clear water reservoirs.

The use of the hydraulic jump was considered and approved for the purpose of mixing chemicals, water being admitted from the upper forebay to the rising well and controlled by a mechanism actuating through floats and controlling the hydraulic inlet valve. After passing over the hydraulic jump, the water passes through the usual type of sedimentation tank and flows directly on to the filters through ports controlled by sluice gates, the wash water channel and troughs being utilized for both the admission of sedimented water and the withdrawal of wash water.

The first unusual feature is perhaps the pipe gallery, with its arrangement whereby a traveling crane can be installed, hung from the upper beams, for the purpose of erecting and handling the control parts and pipes. The use of victraulic couplings rather than the flanged connections was contemplated, and, in my opinion, offers considerable advantage.

The second unusual feature is the sand strainers for the underdrain system. Instead of making use of any of a group of patented arrangements, either of sand valves or special grids, I have recommended the use of a cast iron cover over a concrete trough, with a simple design of manifold cast integrally with the cover. This in itself is not unknown, having been used by Mr. Hunter at St. Catharines. The unusual feature is that instead of screwed or leaded joints, I propose

to use a tapered push joint for the radial 1½- or 2-inch pipes, and hold them in place with a concrete haunch along the base of the tank. The arrangement has several very important advantages. It is incapable of a leakage greater than that from any one of the openings, and it is incapable of breaking away from the main header, as has been the case in some of the screwed or leaded pipes. It also appears to be a most economical arrangement.

The next feature of interest has to do with the storage of chemicals. The plant which I was designing was to be such that it could be operated by the existing personnel, with the occasional inclusion of ordinary labor for special purposes. For this reason, instead of using overhead storage and trying feed machines, as is most convenient and satisfactory in many plants, I used a portion of the foundations for wet storage of a saturated solution and capable of receiving several cars of chemical. The chemical is taken from the cars and discharged down a manhole to a lower bin, which is immersed in water. When the storage is first charged, a portion of the chute will be full of undissolved chemical and will remain so until the use of chemical will have dissolved out the portion supporting the overlying mass. It was my intention to pump the concentrated chemical to a solution feed machine actuating from a constant level, diluting the solution as the reactions intimated were advisable.

In addition to alum storage, I purposed having a track work suspended from the ceiling of the screen room, so that I could use drums of ferric chloride, either to supplement the alum or to displace it entirely during periods when the ferric chloride might be suggested as the more suitable chemical.

In the screen room, while it is not an unusual feature, the arrangement is specially adapted to the removal of frazil ice. The screens themselves are of the sloping rather than the vertical type, so that they can be elevated out of the water, should conditions be acute. After passing the screens, the water flows directly over the jump and through the settling tank, and then on to the filters. Instead of using earth on top of the settling tanks, I thought it advisable to insulate them with cork or other suitable material. According to the estimates, the difference in cost was not prohibitive, and it had a great many advantages which determined our policy in the matter. The entire roof of the building is also insulated, to keep down condensation and to simplify heating problems.

In the pumping station we have venturi controls both on the inlet

water and on the water going to the suction well for the pumps. These controls are primarily for the proper application of chemicals. They also actuate the mechanisms which regulate the opening of the hydraulic valves, maintaining constant differential levels.

The piping layout in the pumping station is somewhat unusual in that provision is made for testing any of the several units in use, without throwing the station or other units out of service. The units have both duplicate discharge and duplicate suction lines, as recommended and urged by the underwriters. A by-pass has been introduced, so as to relieve the discharge system into the suction well for testing purposes.

The arrangement for the supplying of power for the operation of the electrical pumps is rather unique, although not novel to this plant, in that it provides an inter-switching arrangement with four of the principal developing companies at Niagara Falls, and precludes the possibility of any shut-down of duration.

It was my intention, in connection with the service pumps, to have push button control on the electric circuits and a hydraulic or electric valve operating the discharge line. The whole arrangement, both of the filter plant and of the pumping station, was such that the operators had a minimum amount of manual labour, and such appliances accessible as would permit the keeping of the staff down to the irreducible minimum.

Since this paper must be short, to permit of any discussion on the subject, I suggest that any features that have not been dealt with in these few remarks might be discussed in reply to any questions that the members might ask. I appreciate that, as operators, many of you are looking forward to the time when you could get possession of an ideal plant. I may say in conclusion that the reason for some of the unusual features we have been discussing is owing to the fact that, like yourselves, I also have had dreams and have attempted in this project to simplify the operations as much as possible.

CUSTOMER ACCOUNTING IN THE DETROIT DEPARTMENT OF WATER SUPPLY[1]

By Hal F. Smith[2]

The present paper does not presume to be a treatise on proper accounting methods or a discussion of the relative merits of various accounting systems, but simply a description of the customer accounting plan used by the Detroit Department of Water Supply. We hope that it contains some points that will prove helpful in the solution of your accounting problems.

The Customers Accounts Division is divided into three bureaus, the Assessment Bureau, Customers Accounts Bureau, and the Collection Bureau. The work of these bureaus is so closely related that it is difficult to draw a definite line between them. For that reason, only by a sincere spirit of co-operation can a high standard of efficiency be maintained. Fortunately that spirit exists. A clear picture of any customer accounting plan would be incomplete without a description of the meter reading methods, but as Mr. Bowen has described that phase of the work, I shall not repeat.

We have approximately 251,000 active revenue accounts 99.5 percent metered. Meters are read and billed quarterly under the cycle billing plan. The rate is a three step sliding scale structure with a minimum charge and a service charge based upon the size of the meter. Each account is billed for indicated consumption and for service charge, these charges being combined and billed as one item.

Consumers meters are owned and maintained by the Department. No charge to the customer for service to the meter is made except where it is wilfully damaged by him or through his neglect, such as failing to provide against freezing or in allowing hot water to back into it. These exceptions are, however, numerous and are mentioned at this time because it creates one of our problems.

We are operating under the so-called combination bill and ledger plan of customer accounting, using individual ledger cards. The

[1] Presented before the Central States Section meeting, September 19, 1929.

[2] Head Water Consumers Clerk, Department of Water Supply, Detroit, Mich.

three major forms are the ledger card, the bill, and the proof sheet, sometimes called the abstract sheet.

ADDRESS 10752 WOODWARD L-21465 LEDGER 14-16

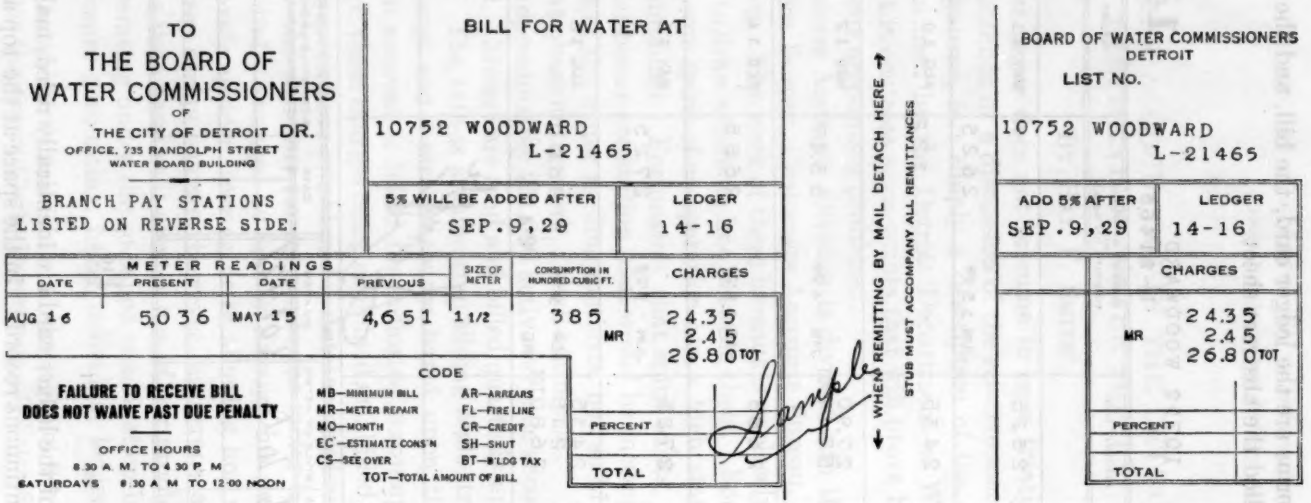
CONSUMPTION	AMOUNT DUE	SUNDRY CHARGES AND CREDITS (IN RED)		METER READINGS	
423	26.25			MAY 11	2,932
		JUN 15'28	26.25		
385	24.35		1.22	AUG 10	3,317
456	27.90 53.47 TOT	JAN 4'29	53.47	NOV 12	3,773
435	26.85	MAR 11'29	26.85	FEB 14	4,208
443	27.25	JUN 5'29	27.25	MAY 15	4,651
385 MR	24.35 2.45 26.80 TOT	SEP 9'29 RE	26.80 2.45	AUG 16	5,036

Sample

DATE		SIZE	STYLE OF METER	NUMBER	DATE		SIZE	STYLE OF METER	NUMBER
6-10	22	1½	W. D.	601428					

FIG. 1

Both sides of the ledger card are identically ruled, making possible a four year continuous record. In the space at the top are shown lot number, house number, street, mailing list number, and ledger



TO
THE BOARD OF
WATER COMMISSIONERS
OF
THE CITY OF DETROIT DR.
OFFICE, 735 RANDOLPH STREET
WATER BOARD BUILDING

BRANCH PAY STATIONS
LISTED ON REVERSE SIDE.

BILL FOR WATER AT

10752 WOODWARD
L-21465

5% WILL BE ADDED AFTER	LEDGER
SEP. 9, 29	14-16

METER READINGS				SIZE OF METER	CONSUMPTION IN HUNDRED CUBIC FT.	CHARGES
DATE	PRESENT	DATE	PREVIOUS			
AUG 16	5,036	MAY 15	4,651	1 1/2	385	24.35
					MR	2.45
						26.80 TOT

FAILURE TO RECEIVE BILL DOES NOT WAIVE PAST DUE PENALTY

OFFICE HOURS
8.30 A. M. TO 4.30 P. M.
SATURDAYS 8.30 A. M. TO 12.00 NOON

CODE

MB—MINIMUM BILL	AR—ARREARS
MR—METER REPAIR	FL—FIRE LINE
MO—MONTH	CR—CREDIT
EC—ESTIMATE CONS'N	SH—SHUT
CS—SEE OVER	BT—B'LDG TAX

TOT—TOTAL AMOUNT OF BILL

PERCENT	
TOTAL	

Sample

WHEN REMITTING BY MAIL DETACH HERE

STUB MUST ACCOMPANY ALL REMITTANCES

BOARD OF WATER COMMISSIONERS
DETROIT
LIST No.

10752 WOODWARD
L-21465

ADD 5% AFTER	LEDGER
SEP. 9, 29	14-16

	CHARGES
	24.35
MR	2.45
	26.80 TOT
PERCENT	
TOTAL	

Fig. 2

number. The headings at the top of the vertical columns indicate their use. Each space set off by horizontal lines is for one billing period, which is identical with our balancing period. It is absolutely essential for balancing purposes that each entry made to the card be made in the proper space, as most entries are not dated. The space at the bottom of the card is ruled for the meter record.

The bill form is self explanatory. You will note that current rates are shown in the net amount only, and that the bill carries the notice that a 5 percent penalty charge will be added after the indicated due date.

The abstract sheet is ruled to receive carbon impressions of the bill. The purpose of this important form will be later described.

For the benefit of those who did not hear the paper on meter reading, the city is divided into three zones, each zone into twelve districts, and each district into routes. Each route contains a sufficient number of accounts to represent one day's work for a reader; they average 165 accounts. This reading unit is permanent, and is used as our balancing unit.

A moment's consideration of the above described division of the city will make clear the principle of cycle billing. Remember that each account is billed every three months. We have three zones. Therefore, one zone must be billed each month. Each zone contains twelve districts, and as the twelve districts must be completed in a month, each district must be completed in approximately two days. That is, each operation in each district must be completed in two days, whether it be reading, billing, collecting, balancing, or any of the other operations, if schedule is to be maintained. It is thus seen that every operation is a continuous one, thereby eliminating peak loads and making an even flow of work, not only possible, but absolutely essential.

Meter reading sheets are arranged in the order found to be most suitable for reading. They are locked into a binder, making this order permanent. Ledger cards and addressograph plates are filed in identical order of the reading book, thus eliminating any sorting at the time of billing. Ledger cards are filed in a room used exclusively for that purpose and may be withdrawn on requisition only. This practice has almost entirely eliminated the lost or misfiled card.

Every operation which, in our opinion, can be done practically by machinery is done by machinery. With the present wide range of

highly efficient bookkeeping and calculating devices, there is very little need for long hand methods or mental calculations. With the exception of a battery of comptometers, we are entirely equipped with Burrough's machines, using their public utility machines for billing, their cash posting machines, and their various type adding machines.

While this general discussion is on, it might be well to describe our mailing list plan. All bills are delivered by our own force, directly to the premises served, except when requested otherwise by the owner. Approximately 30,000 owners have requested otherwise, that is, they have requested that bills for their properties be mailed either to themselves, to a certain real estate management company, or to a trust company. Out of our total of 251,000 accounts, the bills for approximately 75,000 are mailed in accordance with the owner's instructions. This volume demands a carefully thought out system in order to give the customer the kind of service he expects and deserves and yet hold to reasonable costs.

Our plan is this: Every owner, desiring this service, lists his property, giving the name and address to which the bills are to be mailed. A list number is then assigned and this number is applied to each ledger card affected, and to the corresponding addressograph plates. Then an addressograph plate is made carrying the mailing address and the list number and filed numerically by list number. From this plate two index cards are printed, one filed alphabetically by name and the other numerically by list number. Since the list number has been applied to the bill addressograph plate, each bill will carry its proper list number. The last operation, before turning the completed bills over to the Assessment Bureau for delivery, is to pull all bills bearing a list number. These are then sorted into numerical order by list numbers, thus throwing all of a like number together. This sorting, completed, they are sent to the Addressograph Department, where the corresponding mailing plates are pulled, and with them envelopes are addressed. The envelopes will also bear the list number and will be in the same order as the bills. It is then but an operation of putting bills bearing a certain list number into the envelope bearing the same number. Special sorting equipment and an electric envelope sealer are used.

Consumers accounts are opened upon receipt of the meter installation report, at which time an addressograph plate is made and applied to a ledger card, upon which is entered the meter installation

record. The card is then regularly filed in readiness for the initial billing.

Sundry debits are posted by machine to the ledger card prior to the billing date. Our sundry debits consist of meter repair charges, penalty charges, refunds, and debit transfers. All items posted to the card are immediately reported to the control keeper for entry to the control ledger.

Meter repair charge slips are received daily from the meter shop. They are indexed as to ledger number and sorted to districts. Total charges for each district are ascertained and entered to a memorandum ledger. These slips are then filed by districts. The day before District 11, for instance, is to be billed, all charge slips for that district are turned over to the debit poster, together with the corresponding ledger cards. Each item as posted to the card is transferred to a proof sheet by use of a duplicate carbon roll. At the end of each control unit, a transfer total is taken, and at the end of a district, a grand total. The grand total must agree with the above mentioned memorandum ledger. The proof sheet, showing totals charged to each control unit, is turned over to the control keeper.

As previously mentioned, Burroughs public utility machines are used in our billing work. As most of you know, this machine types the bill, ledger card, and abstract sheet at one operation; the card and bill receiving original impressions, the abstract sheet being a carbon copy of the bill. The machine is so constructed that there is a mechanical assurance that certain operations are properly performed. It is equipped with a lock that prevents a change in the key set-up during an automatic repeat print operation, thus assuring that the charges shown on the bill are identical with those on the cashier's stub. Another check that the machine makes is the verification of the meter reader's subtraction. The operator follows the reader's figures. If the billed consumption does not represent the difference between present and previous readings, the machine will automatically indicate the error on the ledger card.

Billing assignments are made by reading books, which is equivalent to our control unit. The operator receives the reading book, addressed bill forms, and corresponding ledger cards, all of which are in the same order. She first puts in the present and previous dates and readings, then consumption, followed by the rate charge, which she calculates either mentally or by reference to a rate chart. The next step is to put in any unpaid balance as arrears, followed by the

posting of sundry debits, if any, and then to show the total charge, which is, of course, a machine operation. Our standard production rate is set at 800 bills per day per operator. Actual production is running very close to this figure.

Bills are proven for accuracy in the internal audit and control division of the Bureau by means of balancing the proof sheet. A detailed description of this operation would be too lengthy and too hard to follow, without having a sheet before you, but it may be said, in a general way, that the proof rests in balancing the amount obtained by applying the rate to the total rate revenue of the sheet. This necessitates, of course, grouping water sold at the various steps, grouping the various service charges, and making corrections for certain rate peculiarities. Any one interested may refer to the display board where a balanced proof sheet clearly illustrates this operation. Any bills found to be in error are sent back to the billing division for correction. The balanced proof sheet not only certifies to the accuracy of the billing, but also supplies our trial balance, revenue distribution, and serves as the basis of all our statistical data.

It is the practice in some highly organized and very efficient utilities to hold up the posting of cash to customers accounts until after due date, thereby simplifying this work, and, of course, reducing costs. We tried this and distinctly did not like it. Water accounts in Detroit are not accounts with certain individuals, but with legally described pieces of property. Either the tenant, owner, or agent may pay the bill. Some confusion naturally results, causing considerable inquiries as to whether a certain bill is paid. These inquiries are usually received before due date. We want to be able to reply that the bill is paid or unpaid, rather than to report that the bill is unpaid, unless paid within the last ten days, in which case it would not show on the ledger.

A practice has been adopted, therefore, and rigidly maintained, of posting all cash received, on the following day. Bills are paid in person at the main office, by mail to the main office, and to banks and their branches throughout the city. In order to post cash the day following its receipt, it is necessary to sort stubs and pull ledger cards immediately following the close of the day's business, so as to have them ready for posting the following morning. A night force consisting of one senior clerk and four juniors do this work. They also run a tape of the stubs, taking a transfer total at the end of each control unit, and a grand total which should agree with the cashier's reported

total. Ledger cards are pulled for posting, only from the inactive districts; the active districts are posted directly from the trays. The amount of each stub is posted in red ink to the corresponding card by means of a posting machine, which also makes a carbon impression on the proof tape. A transfer total is taken at the end of each control unit and a grand total at the end of each district. The transfer totals of the proof tape are then checked with the transfer totals of the tape run by the night clerk. Should there be any discrepancy it is immediately located and corrected so that at the end of a day's posting the total of the district totals will agree with the cashier's report. No difficulty is experienced in this operation. The tape run by the night clerk, which has been checked with the machine posting tape, is turned over to the control keeper for entry.

We should like to post penalty to all unpaid accounts immediately after due date, but this is impossible on account of bank payments. Most banks, and their branches, are very prompt in making returns, but due to a few, we do not feel safe in posting penalty until twenty days after due date. At this time a clerk, using a posting machine identical to the cash posting machine, except that it is equipped with a black record ribbon, posts the penalty charge to all accounts showing an unpaid balance, and to all accounts paid after due date. A transfer total is taken at the end of each control unit. A proof tape is used on this operation in exactly the same manner as in cash posting, and when the district is completed, the tape is turned over to the control keeper for entry. This operation is a continuous one, posting penalty to one district after the other, in accordance with schedule.

At this point, collection work breaks into the picture, as the clerk posting penalty, also establishes the shut off list simply by setting aside all cards to which she has posted penalty that carry an item of arrears, indicating that not only is the current bill unpaid, but also all or part of the previous bill.

Our collection system is somewhat unique in that no delinquent bills are sent out. We are operating on the theory that money spent to collect a bill that we have every reason to believe will be paid without collection expense, is just so much money wasted, and further, that a good customer is unnecessarily annoyed. The plan is this: If a customer fails to pay a current bill, there is nothing done about it, provided that the account is paid in full to the current quarter. However, should this account still be unpaid at the time of the next regular billing, the unpaid balance is posted to the bill and

the following form attached. If this account is not paid in full by due date, it is pulled by the penalty poster as above explained; a delinquent bill, giving all necessary data is made out and turned over to the Collection Bureau with orders to collect or shut.

All entries to the ledger card made at any time other than the scheduled time for that particular operation, are considered ad-

ABSTRACT SHEET

FORM SM-6

OPERATOR Glenford LED. NO. 11-28 AD 1ST A/C 994 Oakhaven SHEET NO. 2

PRESENT READING		PREVIOUS READING		SIZE	CONSUMPTION	AMOUNT DUE
JUL 30	21,139	MAY 7 M	14,419 2		6,720	286.30
AUG 3	1,036	MAY 10 *	990	5/8	46	3.59
AUG 3	950	MAY 7 —	941	5/8	9	1.25
JUL 30	487	MAY 10 —	415	5/8	72	5.28
					AR	33.17
JUL 30	977	MAY 14 —	859	5/8	118	8.00
JUL 30	75	MAY 10 —	61	5/8	14	1.51
JUL 30	156	MAY 7 —	84	5/8	72	5.28
JUL 30	265	MAY 7 —	245	5/8	20	1.90
AUG 5	167	MAY 7 —	144	5/8	23	2.10
JUL 30	80	MAY 7 —		5/8	80 EC	5.80
					AR	6.64
						12.44 TOT
					10,647	623.00 ✓

RATES				SERVICE CHARGE				LEDGER CONTROL			E.M.
CONSUMPTION IN THOUSAND CUBIC FT.			AMOUNT	38	¾"	22	80	RATES	545	91	
2287	@ 65c		148 66	5	¾"	4	50	BUILDING TAX			
2640	@ 50c		132 00	1	1"	1	80	C.S.			
572	@ 40c		228 80		1¼"			MISC	74	41	
				1	2"	6	00				
20	MIN		1 30								
								TOTAL	620	32	
Gain 11	-½ ¢		06					CREDITS	2	68	
		TOTAL	510 82		TOTAL	35	10	TOTAL	617	64	E.M.

FIG. 3

justments. All items posted to the control at the scheduled time are reported to the control by proof sheets. All entries made at any other time are reported to the control by adjustment slips. Under the classification of adjustments, then come; final bills, special bills, cancellations, refunds, transfers, and sundry debits. All adjustments are handled by the adjustment clerk, who makes the required entries to the card, writes the adjustment slip thoroughly describing

the transaction, and presents it to the head of the bureau, or his assistant for an O.K.

You will probably agree that a customer accounting system that

TABLE 1

Water distribution analysis, July 1, 1928, to July 1, 1929

CLASS CONSUMERS	RATE	NUMBER OF ACCOUNTS	CONSUMPTION	PERCENTAGE OF PUMPAGE
			cubic feet	
Domestic	Standard	221,904	3,025,339,091	24.87
Commercial	Standard	22,445	2,450,158,852	20.14
Manufacturing	Standard	1,796	2,307,725,857	18.97
U. S. Government	Standard	21	10,671,000	00.08
Suburban	Double	3,343	1,382,023,100	11.36
Semi-charitable institutions	Half	32	56,690,600	00.47
Water used for construction purposes	Special*	173	Est. 138,067,780	01.13
Charitable institutions	No charge	41	26,641,700	00.22
Municipal—metered	No charge	527	351,642,600	02.88
Municipal—unmetered	No charge		Est. 976,867,100	08.02
Main and service leakage based on pitometer survey			Est. 608,458,300	05.00
Water unaccounted for			834,881,600	06.86
Totals		250,282	12,169,167,580	100.00
Total pumpage in cubic feet			12,169,167,580	100%
Revenue producing pumpage			9,370,676,280	77%
Non-revenue producing pumpage			2,798,471,300	23%
Consumption revenue			$5,244,144.51	85.79%
Service charge			868,707.33	14.21%
Revenue from sale of water			$6,112,851.84	100.00%
Average revenue per 1000 cubic feet of revenue producing pumpage			$.652	
Average revenue per 1000 cubic feet of total pumpage			.502	

* This classification includes C. S., B. T., and Special Assessments. Number of Accounts for Special Assessment only are shown as C. S. & B. T. are not separate accounts but part of Standard Rate and are so distributed.

Pumpage in this report refers to the amount of water entering the distribution system as indicated by the Venturi Meter.

is not under complete control and in balance both internally and with the general ledger, cannot be considered satisfactory, no matter how well it appears to be operating otherwise. Our control ledger is

entrusted to a senior clerk, acting as control keeper. A master control consisting of 40 controlling accounts, one for each of the thirty-six districts and four for other divisions peculiar to this department, is maintained. This ledger is arranged to show a complete revenue distribution, cash received, and balance outstanding, daily. It is a daily summary of all entries made to customers accounts. The control keeper receives his data from proof sheets and adjustment slips, as above described. A mathematical proof of control entry has been worked out and is applied daily. It is practically air tight assuring that entries are made in the correct amount, and in the proper place. Each of the district controlling accounts represents about 7500 customers accounts. This is, of course, too many for balancing purposes, so a control was set up for each reading route consisting of approximately 165 accounts. Since we have at present 1693 reading routes, it means that we have 1693 of these sub-controlling accounts, known as route controls. To these accounts are entered only the balance at the last balancing date and the total daily debit and credit items. If the control is accurately kept, it will show balance outstanding in the corresponding route for any given date. If it were known that no error would ever be made to either control or ledger card, trial balances would be unnecessary, but we all know that in spite of all precautions taken to prevent it, errors will occur, hence a periodical trial balance is essential.

Running a trial balance of customers accounts is often considered a difficult and expensive operation; it used to be for us. It is now one of our simplest operations. You will recall that all unpaid balances are posted to the current bill, hence to the proof sheet. The sum of the individual balances for the route is then the outstanding at that time and should check with the control. If it does not, we have only 165 accounts to look through. The error is found in a few minutes, corrected and the controlling account is balanced.

The small control unit and the cycle plan of balancing have made this possible. The route control, acting as a sub-ledger to the master control is kept in balance at all times with the master control, which in turn is kept in balance with the general ledger by means of a monthly trial balance.

The abstract sheet contains a great deal of information readily available for statistical purposes. The compilation and tabulation of these data are daily routine operations.

DISCUSSION

C. E. INMAN:[3] In signing up customers for water, do you deal with any one except property owners.

MR. SMITH:[2] Our accounts are with property. Application for water is made by the plumber. The Department makes connection with the main and runs it into the lot line. From that point on, it is the plumber's job. The plumber pays for service at the time the application is made and, of course, he charges it to the owner.

C. E. INMAN:[3] In making out bills, some are sent to the property owners and some to the tenants. Do you hold the tenants responsible.

MR. SMITH:[2] No. We send bills to any one requesting them. If it is not paid by tenant, we charge it to the property owner.

MR. INMAN:[3] In other words, you recognize only the owner of the property.

MR. YOUNG: In case the property changes hands and there is an unpaid water bill against it, does the new owner have to take care of that? You cannot give a clear deed to property if a water debt is against it.

MR. SMITH:[2] Water debts are not registered. If the property changes hands, the respective buyer checks up all taxes and water rates against it. As I say, they are not listed in the Register of Deeds office. However, we have carried on a campaign for several years with the idea of educating people to call up or come in to see if there are any unpaid balances. If unpaid bills turn up, the present owner is held responsible. We assist in making adjustments.

F. H. STEPHENSON:[4] I am an employee of the water department in a different department. Mr. Bowen stated that he was able generally to take care of approximately all but four or five complaints per month. Those are referred to an adjustment committee. I am a

[3] Warren, Ohio.
[4] Detroit, Mich.

member of that committee. That committee found in considering these complaints that we get very full information from both sides and we have been able to adjust them.

MR. BUCHANAN: Why do you deliver bills rather than mail them?

MR. SMITH:[2] One reason is that 700 bills in the same district can be delivered by one man. That is cheaper than you can mail them. Our accounts are known by address only. Our men spend more time on getting the bills to the right address than the mail man will or can.

MR. INMAN:[3] No name appears on the bill when it is made out?

MR. HUTCHINSON: The question of mailing or delivering bills is one which I believe will come to the direct attention of the Association before long. I understand that mailing bills comes under a two cent stamp. In electrical utilities, the question has been considered. It might be possible to place the question before the postal authorities at Washington. If they were to accept utility bills under a one cent stamp, they would get a lot of business that they do not get now. New York wanted to mail these bills under a one cent stamp on the basis that they are printed matter. The post office would not accept the utility bills because of various amounts. It might be possible for the utility members to approach the political authorities and arrive at an arrangement to bring them under the mail. Possibly at a later date the thing can go through.

MR. INMAN:[3] We mail all of our bills and deliver for one cent. The bill is made on a postal card.

D. C. GROBBEL:[5] In delivering bills by mail on a postal card, there is a question of psychology involved that will be detrimental, more or less. We in Detroit do not approve of postal cards. We do not believe that every village post master should know what his neighbors bills are. And they are very prone to read postal cards. It does not look quite business like. It seems to be a violation of the relation between seller and buyer. Then there is the difficulty of getting a postal card of a size small enough to add a stub to it with the necessary descriptive matter. It is confusing.

[5] Detroit, Mich.

I had the matter up with one of the four largest cities in Ohio, which now uses postal cards. They are going to eliminate the postal card system altogether as far as mailing is concerned. It is a cheap method if there are long distances between the premises, but in the case of the city of Detroit the bill deliverer gets his stuff in a certain district and goes from house to house. If the premises are vacant that bill comes back to us.

Regarding the postal question, we were prohibited for a long time from putting bills in post office boxes under a ruling of the post office. There was no foundation therefore. It was a ruling of the common council. Some months after this ruling went into effect prohibiting anybody else putting any thing into the boxes for mailing, we threatened to have the ordinance repealed and we were permitted to put the bills in the mail boxes. There is a question whether mailing bills would be any cheaper than delivering. When our men deliver 700 bills a day, the least we could get those into the mail for is $21.00 or $22.00. It costs $8.00 a day for a man to do it.

Most of the postal card systems that I have seen use hand methods. It is a tremendous waste of energy to set a man or woman at a ledger to write bills by hand when there is so much mechanical equipment that can be adjusted to the uses of the department. If more mechanical equipment was used there would be less postal card bills sent out. I venture to say that very few water departments send out as high a number as we do, 700 bills per day per girl. Getting out that many bills per day per girl includes more than making the bills. It includes the ledger entry, changes for making entry and on top of that we get all sort of figures that are useful and needful to the department. If we destroyed all the machines we have today, we would set the whole force making machines. Meter readings, bills, accounting and everything are working on schedule. We have almost a regular Ford production system. We can not conceive of going back to the old system of having a crowd of clerks writing out bills by hand, making entries in ledgers by hand or posting cash by hand. That may be possible in smaller communities where a part time clerk handles all that work, but when you have more than a quarter million consumers you have to adopt mechanical methods. I believe it would pay even the small water department to consider mechanical equipment in their offices.

CHAIRMAN BANKSON: Do I understand you to say Mr. Grobbel, that postal cards are not made out by mechanical methods?

D. C. GROBBEL:[5] Not under ordinary circumstances. Most of them I have seen are not. You will find the postal card used in small communities where there is a lack of mechanical equipment. In the particular city I had in mind, they had typewriters. After running cards through the addressograph machine, they used typewriters. It was a duplication of work.

MR. HUTCHINSON: I would like to say that postal cards are being used mechanically but one big draw back is that you cannot use the automatic addressograph system on the postal card. One side has to be made parallel and one side perpendicular.

MR. INMAN:[3] I am upholding the postal card system at the present time. We use billing machines and addressograph. We make two impressions, one on the face and one on the stub at the same time. We have no reason to object to the postal card.

D. C. GROBBEL:[5] Some day they will be able to use an automatic addressograph machine on the postal card. We ran up against a proposition where we did not have to reverse the plates. Our routes are built up geographically. We paid $3400.00 for an automatic addressograph. We had to reverse the bills by hand to get them into the addressograph. They put an automatic reverser on the automatic addressograph and as the bills come out they are reversed. Then they are in shape for billers.

In former days, men who used mechanical equipment encountered stub accounting, the so-called Baltimore system. We do not believe in stub accounting because it leaves a bad impression in the mind of the customer, if we have to go up in the attic and pick out stubs for the last two, four or six years.

ROY B. CHAMPION:[6] Ordinarily a customer inquiring as to his account is shown the original meter reading sheet, with the original entry made by the original reader. After all people generally are more interested in the original than in something which has been transcribed. We make our bills in triplicate. When bills are ready to be delivered the third stub is detached and kept in the office. As the case or check is brought in, we match the stub with the stub in the

[6] Holland, Mich.

office. We have found that works out very well indeed. We only post about ten percent of our accounts delinquent.

D. C. GROBBEL:[5] What does he do with that meter sheet? How are you going to satisfy a customer if the meter is fifteen miles out in the country? If you only post 10 percent of your accounts as delinquent, you have too many delinquent accounts.

MR. BUCHANAN: My experience would not be worth anything probably, but if I give it, it might start some others working back here. We have about 3000 consumers scattered over 11 square miles. We tried to mail the bills. It did not work. The post office could not find them, with what effort they put into it and for different reasons. Sometimes names were written poorly, there were many foreign names and a great turnover in population. It was a suburban village. People bought homes and lost them on foreclosure. We mailed the bill to the property owner, unless the property owner wants the bill mailed to some other address. We were troubled with responsibility for the bill of the former owner. I do not believe there is any question in Ohio that we could not make it stick. If John Smith lost a home, sold by the receivers sale, the fellow who takes it over will pay the bill. If it is sold by Court order or sheriff sale, they will pay the bill.

D. C. GROBBEL:[5] There are just as many rules about the charges for water as there are minds in the various communities, village or city council. There is no standard practice. A lien is not worth much. You cannot enforce it. Unless you can reverse the Supreme Court decision in the case about twenty years ago where they decided that the operation of the water plant was a private and not a governmental function. What process is to be followed to obtain your money is going to be left to the ingenuity of the man who is handling it and a bluff will go about as well as anything.

MR. LECHNER: In Erie, a water bill is a lien against the property. We bill the owner and refuse to send the bill to the tenant. We require a written order from the owner in advance of turning water on the premises. Our losses are practically nil. I do not remember when we charged an account to bad account.

A. L. McCandless:[7] In Ohio the village has protection and I think the city has a similar right and more in that they can pass their own ordinances. In the city of Cleveland, in one instance I received about $98 on a second mortgage on property. I do not enjoy the thing a bit, but the rest of the town should not be victimized by unscrupulous tenants.

Chairman Bankson: There is one phase of this situation that I have been looking forward to with interest and that is to see what might happen by reason of the development of holding companies with their program of standardization. At least one holding company practiced very little jurisdiction over the methods of the separate offices, which was rather surprising to me. If it is in order, I should like to ask whether any progress is being made by any of the holding companies towards a final uniformity of progress in the different plants. Mr. Hutchinson, have you any information in that connection?

Mr. Hutchinson: I work with the Federal System, and have the opportunity of working with the holding companies as they organize. We studied each different type of billing machine. We investigated the register plan and used the Elliott Fisher machine. We studied the possibilities of all stub plans on other machines and the possibilities of bill and manifold systems of commercial houses. Naturally in the Federal System, we have operating representatives who are of high standard. Some of them have very conservative ideas and there was a considerable amount of work to be done to get these men to agree on one system.

The stub system I mention was first put in in Pennsylvania. The system has been approved, by each of the operating officials. In the smaller plants we install the central billing system. Where the central billing system is impractical, we use cards or ledgers. For that reason the stub system works in very satisfactorily. Meter sheets are read in local offices and carefully prepared data are mailed out heavily insured to billing offices. These meter sheets arrive and bills are prepared immediately and the prepared bills are checked and proved. A copy of the abstract sheet or copy sheet is retained in the billing office and another copy is sent to the local office together

[7] Euclid, Ohio.

with the meter sheets and bills. The local office checks up and collects the bills. This system has been placed in offices where we had a small number of consumers. It works out satisfactorily. It is doing away with bookkeeping knowledge. It is no longer necessary to have employees who understand bookkeeping. They do not have to do anything but keep a control book. They put the total on one side and on the other they record cash received each day, enter any adjustments on either side and they have a continual balance of their accounts. We have done away with the trial balance procedure. Everywhere we have placed this system people have been satisfied with it. The finding is one that took considerable time. The Federal organization went to considerable expense to do it.

Outside of consumers' billing, it was found necessary to standardize all accounts and local office procedure. Today we are going further. Our operators have seen the work we have done in the accounting department and all business departments are following the practice of standardizing as closely as possible the office forms and procedures. That, of course, is subject to a great extent to the state commissions. Very few states have standardized methods. It also makes it possible should we require an extra person in some office to transfer one from another office or from our general office. I think that anybody who wants to study the standardization of methods both in accounting and operating will do well to study what has been done in the Federal organization.

MR. YOUNG: Probably in every case that privately owned companies have a lien against property for unpaid water bills, the company has a deposit for advance payment. They are required to pay interest on this deposit. That needs accounting. I would like to know whether in the larger companies they have a deposit or advance payment.

MR. FOOTE: It is a question of security of accounts. I will give two or three examples. The first is the rate schedule which provides for a minimum prepaid each month. We have one or two such rate schedules in our organization in line with most modern rate schedules of business. The minimum charge or service charge covers service. The second consumption charge represents the operating cost in delivering water day by day. If you had a completed water

rate you would have another step in your rate which would represent the account for water delivered and collecting of money. I do not think any rates isolate the third step. In all cases we would have a minimum prepaid amount deposited by the consumer. In our plant we find the system very satisfactory. It has been a case of education. We find that where we do not have the rate which has provided us with a minimum amount in advance we are in trouble. One case arose in my experience in Pennsylvania which was very peculiar inasmuch as there was a delinquent account through the omission of the bookkeeper. It was then shown on the new billing. The following month, the matter was brought up and the man paid the second bill. He said he did not owe us anything. I have paid your service charge up to a certain date. You did not indicate that I was to pay anything further. I took it up with the man but did not get the money.

MR. COGAN: The greatest trouble we have in West Virginia in regard to bills is in abnormal consumption. The commission allows us to demand a deposit if we are on a monthly schedule, an amount equal to $\frac{1}{12}$ of the charges for water. If you are on the quarterly scale it is based on the average charge. Often the consumer runs high bills. The company requires a deposit as high as they can get the consumer to place. We have trouble getting the consumer to put up a large enough deposit. If he refuses to pay the bill all we can do is to cut the water off. Then somebody else in the house signs up under another name. In Charleston we have a large colored population. Each individual has more than one name. If the person receiving the application does not know the individual, we are in trouble. With the abnormal bill we have additional trouble. The quarterly bill is not paid in case the amount of deposit is not paid in excess. We have to keep water service installed until he has used the entire amount of his deposit. That makes a lot of difficulty. He might have a deposit of 50 or 25 percent still due him and we can not cut him off under the law. We have to be very careful.

D. C. GROBBEL:[5] I should like to ask Mr. Cogan how we would apply West Virginia laws to our conditions in the case of Henry Ford, who has a 24-inch service and pays $25,000.00 per month. He shuts down his factory, and we read the meter and it is about $50,000,

could we shut him off? He exceeded the amount of his initial deposit and yet he does not pay the difference.

MR. COGAN: You could shut him off if he does not pay.

D. C. GROBBEL:[5] The same Henry Ford makes his deposit of $25,000.00, shuts down his plant and say, well I paid $25,000.00, I am going to waste $25,000.00 worth of water. We do not want anybody to waste water. Could we shut him off although he paid for it?

MR. COGAN: I do not think we could.

D. C. GROBBEL:[5] I should like to ask another question. We are confronted with a situation where the consumer wants a large meter for short periods. Our rate is based on consumption and service charge. Recently a number of millionaires in Detroit wanted beautiful lawns and used Brook sprinklers about a foot under the sod, and uprights with sprinklers. They have to have a large meter. We have a service charge for a large meter, but we have only three months summer. They object to paying the service charge on the large meter for the balance of the nine months of the year. I was wondering if the Federal Water Company had encountered anything like that.

MR. HUTCHINSON: In West Virginia, the service charge applies throughout the year.

D. C. GROBBEL:[5] And the use of the Sloan valve in the home. The Sloan valve will only operate on a 1½-inch meter. Are people to be penalized for improving the plumbing in their premises by the use of this modern equipment? Take a six or eight room house under ordinary conditions with an ordinary tank closet and a ¾ or ⅝-inch meter, the minute they put Sloan valves in that toilet they have to have a 1½-inch meter.

MR. COGAN: Answering question of large size meter with three months use of service, there was a case of break down service before the Court in Youngston, W. Va. recently. The customer had a large meter and was paying under the Youngston system a second service charge and an additional water charge. The water company put in a

meter to take care of these great demands. Then they would have long intermissions before there would be any other usage. The water commission refused to allow them to do it. Where a man is buying break down service, he pays a certain service or demand charge regardless of whether he uses any electricity throughout the year. He puts that in with his standby system. He is buying water from you. Of course, when the heavens are good to him, he does not need to take any water from your service.

We have the same thing in Charleston in regard to size of meter. People want large meters for small quantities of water. They are much incensed if the water companies will not enlarge their meters, to meet that modification.

CHAIRMAN BANKSON: As a single citation this short season service happens considerably in Florida and other similar sections. The water company serving Palm Beach, Florida, established a new rate on the service charge basis and made an annual service charge payable in advance on January 1, when most of the people were there and needed water very shortly. That process, although intended to be highly successful to the utility was distasteful to the consumers and ultimately I do not know whether it will be a success or whether it will be changed.

MR. HUTCHINSON: I do not profess to know anything about meters. My activity is accounting. But if a man chooses to require a meter that will supply a large demand he has the service there. The company has got to be prepared to supply that water in the summer time and cannot remove their pumps during the winter time. They have to stand for it all the year around.

SCIENTIFIC CONTROL FROM THE OPERATOR'S VIEWPOINT[1]

By R. G. Yaxley[2]

The filter plant at Waterford, N. Y., is a New York Continental Jewell plant built in 1914 with four 0.5 m. g.d. beds. Because of the low consumption of the community, they are operated at a 70 m.g.d. per acre rate. The supply is obtained from the Hudson River and is a soft water, badly polluted with paper mill wastes and sewage, and with an average color of about 55 and at times reaching 100. As usual with this type of water the effective coagulations range on the pH scale is limited, the optimum pH being about 5.95 and a change of 0.15 either way is distinctly noticeable in basin reactions.

In contrast to the plant that obtains its supply from a lake or large storage reservoir, we have erratic changes in alkalinity from day to day. The minimum flow of the river is about 1000 second feet so that industrial wastes can hardly be of major importance, but large power dams on the several tributaries are, no doubt, the main reason for this condition.

The conditions that have to be met are shown in figure 1. These variations take place without any apparent change in stream conditions. Color, turbidity, rate of flow, etc., will remain the same and no warning is given the "rule of thumb" operator that he has a different water to treat from that of the previous day. When it is brought to mind that a change of 2 p.p.m. in alkalinity is equivalent to 8 to 10 points on the pH scale, and remembering that the optimum range is very narrow, the necessity of having some practical check on basin performance is readily seen. pH control has proved to be the answer.

Since February, 1924, sulphuric acid has been used for the purpose. Some of the results obtained are shown in figure 2. This is for a consecutive run of 29 days and the particular time covered shows as great a range in raw-water conditions as one would expect over a much longer period. The color ranged from 65 to 43, turbidity from

[1] Presented before the New York Section meeting, October 3, 1929.

[2] Superintendent, Water Department, Waterford, N. Y.

200 to practically zero, alkalinity from 36 to 16 and temperature from 44 to that of mid-winter. There was high water from November 17 to 21 inclusive. By the 26th conditions were normal with nearly zero turbidity and on the 5th the river froze over. Conditions from the 8th to the 12th were approximately those of mid-winter.

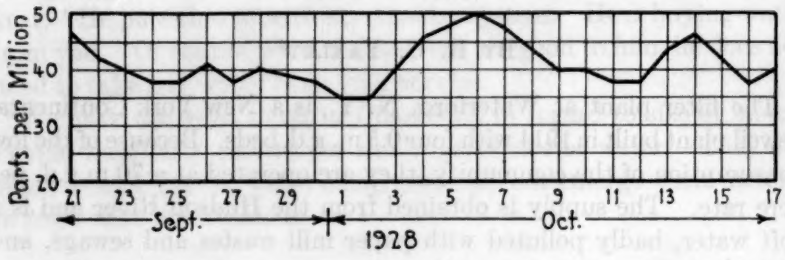


FIG. 1. CHANGES IN RIVER ALKALINITY (METHYL ORANGE)

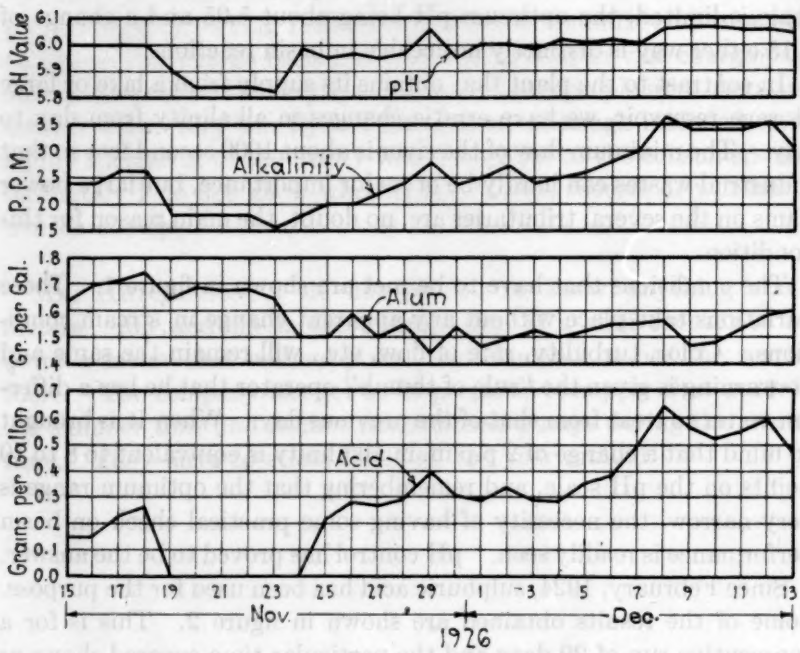


FIG. 2. A STUDY IN HYDROGEN-ION CONTROL

The main point brought out in this study is the fact that with the pH maintained at its proper value, coagulation can be obtained over a wide range of water conditions without any radical change in rate of alum feed.

The alum used was 1.7 grains from the 15th to the 24th and then reduced to 1.5 g.p.g. a change of less than 15 percent. The minor changes shown are caused by the usual variations of a solution feed. The pH values in the basin were, maximum 6.06 and a minimum of 5.82, with an average of 5.97. From the 1st to the 13th the average was 6.02 with a maximum of 6.06 and a minimum of 5.98. At the time this run was made the plant was operating at a rate of about 90 m.g.d. per acre, with two hours basin capacity. The effluent color at no time exceeded 8 and hydrate trouble was conspicuous by its absence. The latter is, in my opinion, an important factor in determining what efficient coagulation is, especially in mid-winter. Those of you who have never been called upon to feed 3 or more grains of alum through a small basin in mid-winter do not realize what inefficient coagulation can do. Hydrate in the effluent, after-coagulation and poor color reduction are only a part of the difficulty. Absorption of chlorine calls for heavy feeds to maintain a proper excess and this in turn causes tastes and odors, with serious complaints from the consumer. As a concrete example of what pH correction will do when conditions are favorable, I shall cite one instance. Some time before we started the use of acid we had a run of very bad raw-water which required 7 grains of alum to get effective coagulation. On a test run 3 grains of alum and about 1 grain of acid produced equal results. This tends to prove that, in some cases at least, alum is being used for the acid radicle only, the excess aluminum not being needed and, under certain conditions, likely to cause serious trouble.

In common with many of the older plants our basin capacity is limited, the detention period being only 1½ hours at normal plant rating. Our present mode of operation, however, gives us about 2½ hours, which is of great benefit especially in mid-winter. The original design of basin provided a division wall through the center forming a single round-the-end baffle, the opening in the baffle being a submerged port. Serious short circuiting occurred, as was proven by numerous tests and several years ago additional wood baffles were installed which effected a decided improvement.

We feed undiluted 66 degree acid by means of a home made, motor operated machine. It is applied to the raw water at approximately the same point as the alum. The machine itself might not be considered the answer to a mechanical engineer's dream, but it is accurate to within 0.02 of a grain in rate of feed, has cost exactly noth-

ing for maintenance over a period of four years and less than $50.00 to build.

We do not use the color standards for pH determination, although they are rapid and convenient. They were used at first but found to be unstable and required frequent renewal, so for several years a

TABLE 1

Bacteria data, January 1, 1927, to December 29, 1928

(106 samples. Results in number of bacteria per cubic centimeter)

SOURCE	MAXIMUM	MINIMUM	AVERAGE	REDUCTION
		Gelatin—20°C.		
				per cent
River	44,875	75	7,603	
Basin	6,600	2	922	87.9
Clear-well	8,400	0 (once)	682	26.0
System	125	0 (9 times)	5.7	99.2
		Bile agar—37°C.		
River	1,000	0 (once)	152	
Basin	175	0 (27 times)	9.1	94.0
Clear-well	5	0 (39 times)	0.25	97.3
System	0	0	0	100
		Acid formers		
River	350	0 (3 times)	60.9	
Basin	30	0 (81 times)	3.1	94.9
Clear-well	0	0	0	100
System	0	0	0	
		Coli		
River	10,000 (7 times)	100 (2 times)	3,000	
Basin	100 (18 times)	0 (13 times)	23.9	99.2
Clear-well	10 (15 times)	0	1.4	94.1
System	0	0	0	100

chart, prepared by Wagner and Enslow and published in the May, 1922 issue of The Journal, has been our sole guide. Titration of a sample taken at the entrance of the basin with methyl orange and phenolphthalein and obtaining the pH value directly from the chart has proved to be a simple and satisfactory method. The values thus obtained may not be absolutely accurate, but the factor of error

is constant and we are not interested in exact laboratory determination, but in practical plant operation.

One unlooked for benefit resulting from the use of acid is that it has an apparent sterilizing effect. The results of 106 weekly samples taken from the plant are shown in table 1. When you take into consideration that 45 or nearly one-half of these raw water samples showed 5000 or more coli and that only 18 outlet samples from a two hour basin were plus in 1 cc., the evidence points, at least, to effective sedimentation if not presterilization. In spite of the rather liberal counts on bile agar and of acid formers there were 27 and 81 times when the basin outlet was negative in 10 cc. for bile agar and acid formers, respectively. In addition to these figures, a series of 22 samples, taken at the basin entrance during the last year, show a reduction of 75 percent in the bile agar counts and 88½ percent in the coli with the sampling point only about two minutes from the application point of the alum and acid. I am not in a position to offer any proof of this hypothesis. I am only presenting certain results for your consideration.

I am sure that some of your are wondering what the quality of the plant effluent from a corrosive standpoint must be when such chemical feeds are required. It has always been a problem. For a number of years lime was used, the feeding point being about half way through the basin, with the usual tendency to destroy floc and put color back into solution.

Several years ago a change was made to soda ash with the feed applied to the high lift pump suction. Improvement in coagulation and filter performance was noticeable and the consumer had the benefit of a much softer water. The average hardness over a period of eight years while using lime was 86 and the two years' average with soda ash is 43. Whipple estimated that each p.p.m. in hardness represents an expenditure for soap of $10.00 a year per thousand population.

Assuming these figures to be correct the saving to our customers is over $1800 per year with an increase in plant cost of less than $300.00.

Careful tests indicated that good aeration of the filter effluent would save nearly enough soda to offset the pumping costs, if a spray nozzle type of aerator was used. In the spring of 1928 such an aerator was placed in operation. It consists of a basin, 29½ feet by 64 feet, with reinforced slab bottom and concrete block side walls. The nozzles are Binks no. 7 and all pipe work is cast iron. The outfit was de-

signed and built by our own crew and is of first class construction throughout. The designed capacity is 1½ m.g.d. and the total cost, excluding pumping equipment, which we had on hand, was $2772.77. A more detailed description will be found in a recent issue of the Engineering News-Record.

Results obtained have exceeded our fondest hopes. Figure 3 gives some idea of the efficiency in CO_2 reduction, a peak of 84 percent being reached in mid-summer. It is of interest to note the loss of

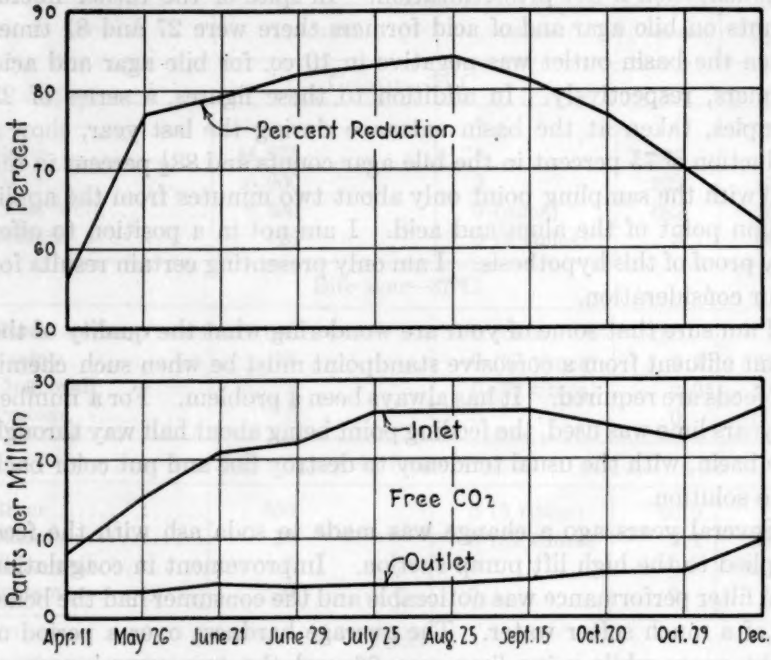


FIG. 3. CO_2 REMOVAL WITH SPRAY NOZZLE AERATOR AT WATERFORD, N. Y., 1928

efficiency with cold weather. Conditions on December 7 were almost identical with August 25, yet the reduction was only 60 instead of 84 per cent on the August day. The elimination of tastes and odors, which were an annual occurrence during the late summer and early fall, was especially marked and many favorable comments were received from the domestic users.

Incidentally this year afforded a fine example of that point. We went into the winter with low water conditions general in our section

following a dry fall. Tastes and odors caused considerable trouble all through the season and at times were serious. We ran a six weeks test with ammonia and also tried permanganate of potash, without results. Twenty-four hours after the aerator was started this spring the trouble was entirely gone.

Aerators are common things nowadays and I mention it at this time because of a singular phenomenon which showed up. I refer to a radical reduction in the soap hardness of the aerated water. This reduction amounted to as much as 37 percent at times and has not, as yet, been explained to my satisfaction. Several engineers have stated that the high CO_2 in the influent gave a false reading, but

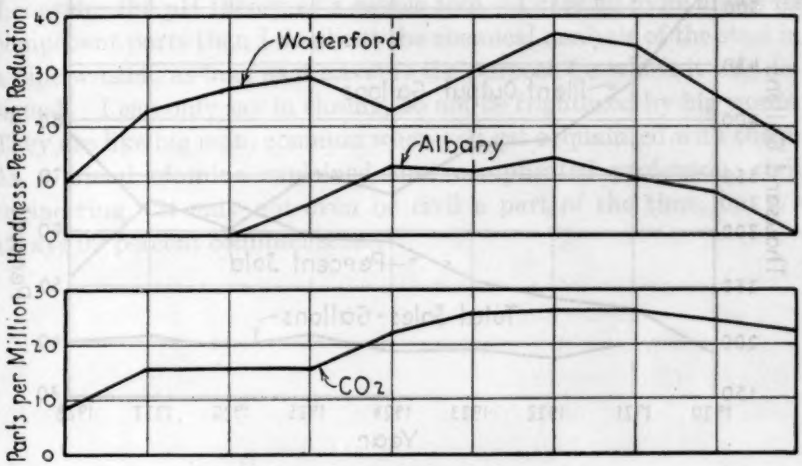


FIG. 4. HARDNESS REDUCTION BY AERATION

figure upsets that theory by a comparison between the aerator in question and one at Albany, which is also of the nozzle type and situated on the same river, but using a slightly different water owing to the entrance of the Mohawk River, which occurs below Waterford. The lower curve shows the CO_2 content of the influent, the records of the two plants being searched to find days when conditions were identical. The middle curve is the hardness reduction, in percent, by the Albany aerator and the upper is that of Waterford. Conditions were as near alike as possible, even to the same solutions being used by the same man as a check on the tests. What causes the difference?

My last graph will apparently have little bearing on "scientific control," but what do these words mean beyond the careful and cor-

rect use of known principles and that is what has brought about the results shown in figure 5.

This plant was over 96 percent metered in 1920 and was considered to be in good shape, yet a careful inspection showed many leaky service pipes, etc. and at least one blow-off open. The total sales were 38 percent of production. These faults were remedied and strict attention is given to the amount of water used from storage during the early morning hours, with the result that 78 percent of the plant output was sold through our meters in 1928.

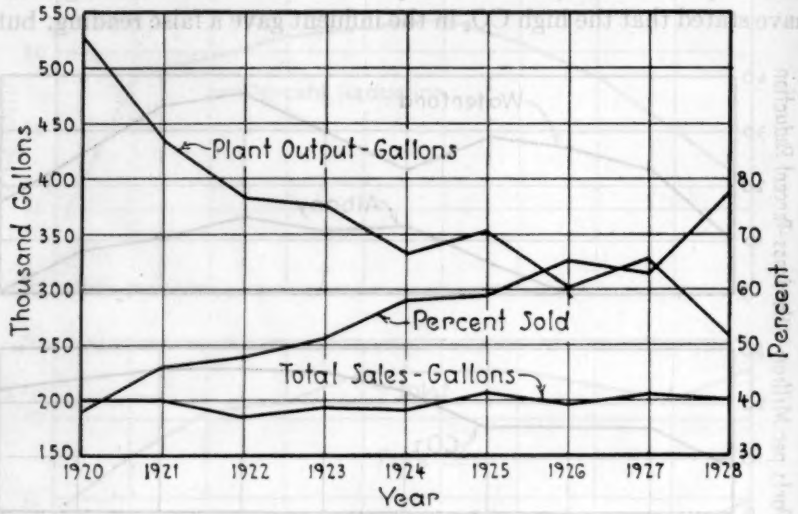


FIG. 5. PRODUCTION AND SALES

The production curve peaks in 1925 and 1927 were caused by broken mains. The trouble, occurring in mid-winter, required some time to locate, with the result that considerable water was lost in each instance. It would be natural to expect that such a reduction in unaccounted for water would show in the financial records. Operating expenses in 1920 were over $25,000.00. In 1922, after the pumping station was changed from steam to electricity, they were still over $18,000.00. For the year ending August 31, 1928 they were $13,700.00. The latter figure covers all expenses, except new construction and interest and principal payments on our debt, and includes all office expenses, meter reading and general maintenance, repairs, etc.

The system consists of nearly 12 miles of mains, two steel standpipes, filter plant, pumping station, office building, shop, etc. and the water is pumped against a total head of over 300 feet.

Many of us are prone to shy at theory, or the actual use of it at least, but what benefit to the public in general would occur if the results of the scientific research were left locked in the laboratory. The theory of pH is as far over my head as Einstein's famous expositions and if I had attempted to start at that end I am sure that I would be with that considerable number who, having become enough interested in the last few years to purchase books on the subject, found themselves completely submerged and gave up in despair. I consider the pH theory as a simple tool. I care no more about its component parts than I do about the chemical analysis of the steel in a pipe wrench, as long as it answers the purpose for which it was designed. I can only say in closing, do not be frightened by big words. They are like big men, common when you get acquainted with them. As a friend of mine explained that complicated profession, civil engineering, "it may not even be civil a part of the time, but it's always 99 percent common sense."

A SIMPLE COLOR TEST OF FLOC IN TREATING COLORED WATER

By George G. Nasmith[1]

In order to obtain data which would be useful in the design of the 34 million gallon rapid sand filtration plant for the City of Ottawa, Canada, a trial filter was designed by the consulting engineers and operated under their supervision for a seven months' period. This trial filter consisted of two independent units, each including a concrete mixing chamber, settling tank, filter pump, control apparatus, chemical administration equipment and other necessary essentials including a laboratory. Each complete unit was designed to treat 48,000 Imperial gallons per day at the rate of 105 million Imperial gallons (125 million U. S. gallons) per acre per day.

In practice one filter was always operated as a control and variations made on the other. After the necessary preliminary tuning up to get both filters operating exactly alike a single change would be made in some feature of the treatment or method of operation in one filter and the results compared with those from the control.

Ottawa river water has a color of 65 to 80; a turbidity of 8 to 45; a total hardness of 45 to 70; a pH of 7.0 to 7.4 and an alkalinity of 18 to 38 p.p.m. To obtain good settling and long filter runs two things were necessary. The first was the conversion of all the precipitated material into well formed settleable floc; the second was providing suitable conditions under which most of this floc could settle out.

During the first three months work on the trial filter the filter runs were short, settling seemed poor and the amount of floc passing over to the filters large. There was no simple rapid method of determining how much floc was actually settling in the sedimentation tanks or passing over to the filters. It soon became evident that if we were to understand the process in detail we had to find a rapid method of estimating the quantity of floc in samples of the water taken at any point. The gravimetric method was too slow and cumbersome for our purpose and would have been useless for checking or controlling the process at any stage.

[1] Of. Gore, Nasmith and Storrie, Consulting Engineers, Toronto, Can.

The idea struck the writer that, as the color removed by the alum floc constituted part of the floc, it might be possible to measure the color in a given sample of flocculated water and take that as the measurable component.

It was argued that, if a sample of water containing floc were treated with acid to dissolve the floc, the color would be freed and could be measured accurately; also that the quantity of color so found could be fairly assumed to represent a similar quantity of floc.

METHOD

1. Preparation of color standards

Filter raw water to remove turbidity and estimate color accurately. Add five drops dilute sulphuric acid and estimate color again. This should be lower than that of the raw water. To 50 cc. Nessler tubes add measured volumes of acidified raw water to obtain colors over the range required and fill to the mark with distilled water.

2. Find what color represents 100 percent of floc present

Take a sample of water from the first mixing chamber where it is known that 100 percent floc is present and add about five drops dilute sulphuric acid. This dissolves the floc and produces a colored liquid whose color is easily matched. Thus raw Ottawa river water has a color of 70; acidified Ottawa river water has a color of 60; and acidified sample from first mixing chamber has a color of 60.

3. Estimation of floc removal

Fill a 50 cc. Nessler tube with a sample of the water to be treated, add five drops dilute sulphuric acid to dissolve the floc and compare with color standards. The table used follows:

COLOR	PER CENT REMOVAL
60	0
50	16⅔
40	33⅓
35	42
30	50
25	58
20	66⅔
15	75
10	84
5	92

This colorimetric method of estimating the amount of floc is, of course, only of value in the case of a colored water. It proved to be of special value in our trial filter where it was necessary to establish exactly what was occurring at every stage of the process. By taking samples at the entry to the filter we could almost instantly determine how much floc was being removed by the sedimentation tanks at that time as well as the amount actually going on to the filters.

During certain experiments samples were taken at regular intervals all night long by the operator in charge and the color determination made upon them by the chemist next morning. A complete picture was thus secured of what transpired during the whole of the filter run. The length of run was found to vary approximately inversely to the amount of floc going on to the filter and directly to the amount settling in the tank.

In some cases the color test saved days of time. For example, while using the mechanical stirring apparatus at a given speed, the color test showed that instead of more floc remaining in the settling tanks more was passing on to the filters. It was assumed that the floc had been damaged and was not settling as well. In such a case it was useless to wait for the end of the filter run and the experiment was stopped.

On another occasion a temporary rearrangement was made of the baffles to the entrance of the settling tank. The color test a few hours later showed that 16 percent more floc was being retained in the settling tanks as a result of the change and the experiment was continued. In this case the filter run increased to 10 hours with 66 percent floc removal while the control continued as before to remove 50 percent floc and gave a filter run of 5 hours.

After this test had been elaborated and thoroughly tested we made very rapid progress in increasing the length of filter runs. The colorimetric test proved to be an accurate composite yardstick for measuring the results occasioned by any change in the design or operation of the plant, and, more than anything else enabled us to increase our filter runs of 5 to 6 hours in early July to 65 to 70 hours before the end of August.

The experimental work was directed and supervised by the writer, with H. M. Scheak, resident chemist, in charge of the laboratory.

MOSQUITO CONTROL ON WATER SUPPLY RESERVOIRS[1]

By Ernest W. Constable[2]

From the standpoint of health, bodies of water such as lakes, ponds, and reservoirs have a very peculiar feature of mosquito breeding which is of great sanitary importance. They have proved to be the natural haunts of the most troublesome malaria-carrying mosquitoes with which we have to contend in this section of the Southern states. A few facts on the breeding habits of mosquitoes may give a clearer view of this.

There are many varieties of mosquitoes and each of these has its own peculiar habits, just as is true of other living creatures. All mosquitoes in their development must pass through a water stage. Their eggs must hatch in water and in it they must live for a number of days before they can reach the adult stage. Each variety chooses its own particular type of water and in it prefers to breed. Here they are as much at home as the rabbit is in his patch of briars. Out of these types of water they die.

Some choose active, cool water such as springs, spring branches, and creeks. Others choose polluted water such as streams, ponds, and puddles, which are contaminated with sewage, waste material, or decaying matter. Our worst malaria carrying mosquito chooses the quiet, warm, sweet water of ponds and reservoirs. Contrary to what often has been believed, they do not come from sources which are excessively stagnant or foul.

In this exhibition of habits it should be kept in mind that the range of application is wide and that there is much overlapping in breeding. Malaria mosquitoes will produce in places other than ponded waters, but this type of water suits them best. Therefore, reservoirs are among the breeding locations most favorable to them.

Complaints of the suspected breeding of mosquitoes have been registered against reservoirs and this has not been without cause. In

[1] Presented before the North Carolina Section meeting, November 6, 1929.

[2] Chemist-Biologist, Bureau of Sanitary Engineering, State Board of Health, Raleigh, N.C.

the surveys of towns for the breeding of mosquitoes, water supply reservoirs have been found to be among the heaviest producers. A number of special surveys of these reservoirs have resulted in similiar findings. Studies of mosquito breeding on hydro-electric impoundings have shown that impoundings of this nature are among the most favorable locations for the production of malaria mosquitoes. Water supply reservoirs, being essentially of the same nature, are not expected to be, and have proved not to be any exception to this fact. Mosquitoes seem to be interested in the suitableness of a pond for their purpose rather than in the use which we wish to make of it. From the standpoint of the public, intolerance of mosquitoes, both as pests and as carriers of disease, is rapidly increasing. Those occupied in affairs of public health, especially in view of the increase in malaria prevalence during the past few years, view every situation which produces malaria-carrying mosquitoes with concern.

The breeding of mosquitoes on water supply reservoirs has not been gone into at all thoroughly. In fact, it has been only touched upon, but the disclosures call for attention and according to present plans this is to be given. However, the situation is not a problem for one agency alone, but for all who are concerned in the handling of water supplies. Enough has been accomplished in mosquito control to enable everyone to take a part.

Up to the present the methods of control have been devised mostly for situations other than water supply ponds. In view of the use of this water, there is still something in refinement in methods to be desired. However, it is not necessary to await improvement or new devices. Such are desirable and doubtless, in time, will come, but present methods are effective when properly applied and, with due consideration for the use to which the water is put, they may be effectively employed. Those methods generally used are the cleaning up of ponds, fluctuating the water level, stocking with fish, and the application of larvicides.

The first essential in the control of mosquitoes is maintaining a clean pond. For our own best welfare in life, we desire not only a suitable environment, but also some sort of house in which to live, with mosquitoes it is essentially the same. Excess exposure is quite as detrimental to them as to us. In addition to suitable water for breeding, they also must have harbor or retreats of some nature for protection. This they find in the vegetation, debris, and floatage which usually collects in ponds. Both that which is distributed

about the pond surface and that which dips or juts from the shores are of value to them. A clean, free pond area offers them little place to hide and although eggs may hatch, the larvae have little chance to mature; therefore, the value of maintaining a clean pond. The best and simplest means of mosquito control is, wherever possibile, to expose the larvae sufficiently that they cannot survive. There are, however, a number of sections in most reservoirs in which it is not economically feasible to bring about and maintain sufficient exposure to prevent breeding.

Such sections will occur in shallows, flats, bights, bays, and similar areas. This is the case more often in the heads of impoundings and in the heads of tributary streams. Shallowness of water and smallness of areas prevent sufficient action to keep down vegetation and to develop definite shore lines. Inaccessibility to wind and wave action may maintain quiet water for a number of days. Mosquitoes will thrive in such areas even in the absence of harbor, for tranquility will serve in its stead. There are, however, other means which are of aid in controlling such places as these.

Varying the water level from six to eight inches each week during the active breeding season will strand many larvae. Others will be brought out into more open and active areas and thus be exposed to the elements and to natural enemies. But if there are sinks or holes in the bed of a pond that do not drain, this process will only increase the favorableness to breeding there. Wherever the expanse of water is reduced to smaller areas, the tendency is to decrease its activity. For instance, a wind that will whip a large water surface into sizable waves will hardly disturb a small puddle even though these be side by side. In these features again the desirability is indicated of starting out with a pond that is well prepared. It is under such conditions that nature can be brought to do the greatest part in control. It is under such conditions also that fish can be effectively utilized.

A number of fish are natural enemies of mosquitoes to varying extents. There are small surface minnows, native to waters of this section of the country and prevalent in most of our streams, which are especially prominent in this respect. One variety—Gambusia Affinis—is more generally utilized. They will consume quantities of mosquitoe larvae where they can be reached, but the water must be free enough of obstructions to give them access. The fact that they are present is no guarantee of their effectiveness, for larvae require

only a bit of cover in which to hide. As an aid to other means of control, minnows are highly desirable in reservoirs, yet this does not mean that control is complete. Areas will exist in the average pond in which the combination of measures named will fail to keep mosquitoes down. Then recourse may be had to some type of larvicide. There are a number of these available, some especially manufactured for mosquito control, but in the absence of definite data as to safety and worth, only one, mineral oil, is considered here.

The idea of using oil doubtless will raise a question in your minds. However, for satisfactory mosquito control in the average reservoir, some sort of larvicide must be applied, and according to information in hand mineral oil is the most satisfactory thing to use. With proper consideration of the circumstances involved this can be done without detriment to the water supply. Generally, the most difficult areas of a pond to control are those farthest from the supply intakes, and in these areas it requires only a light scum of oil for mosquito control. If it is judiciously applied, little of it is likely to reach the lower end of a pond. Oil also remains on the surface and intakes usually are placed at some depth. There is little likelihood of any of it that does get into intake areas ever entering pipe lines.* Almost all streams carry much larger quantities of waste oil then are ever put in reservoirs for mosquito control.

Almost any of the mineral oils will serve if they are light enough in body to spread well. Kerosene, fuel oil diluted with kerosene, or similarly diluted waste engine oil will serve. The chief point of concern is to have them of such a consistency that they will form the proper scum. Engine oil and kerosene in dilutions of from 4 to 6 parts to 1, serve the purpose well. This, however, is to be judged by results rather then to be prescribed. None of these oils are harmful to fish.

In the use of larvicides, just as in the use of fish, effectiveness is in direct proportion to the cleanliness of the pond. In heavily vegetated or obstructed areas, oil will help to control, but even with the application of large quantities, control will not be complete. For easy, economic, and effective mosquito control, the first and greatest requisite is a pond well cleared and cleaned. In this manner, the greater bulk of the work is put into nature's hands. With this condition maintained, and supplemented by the other features named, there is little reason why adequate control of mosquitoes on water supply reservoirs cannot be realized.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Design and Practical Test of Integrating Flume Meter. J. W. LEDOUX. Eng. News-Rec., 102: 428–30, 1929. Illustrated description of a meter designed by LEDOUX for measuring the discharge through flumes by means of a function of depth of water in the flume. When checked with measurements by a rectangular weir with end contraction the maximum apparent error was about 6 percent and the average error throughout the range of the experiments was 0.55 percent. The only limitation is when conditions downstream from the meter are permitted to cause back water.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Data of a Cloudburst Flood in Rondout Creek. E. A. VAN DEUSEN. Eng. News-Rec., 102: 389–90, March 7, 1929. Data given on phenomenal flood which occurred in Rondout Creek Valley, N. Y., on August 26–7, 1928, as result of cloudburst in upper valley. Ground was fairly well saturated as result of previous abnormal rains and circumstances were particularly favorable for flood. At Honk Falls dam, measurements indicated depth of water of 12.5 feet over crest of spillway. High water measurements showed crest to have been submerged for distance of 70 feet downstream from dam. Discharge at this point was calculated to be 300 second-feet per square mile. Correction: Eng. News-Rec., 102: 607, April 11, 1929.—*R. E. Thompson.*

Miami Flood-Protection Works Tested by High Flood. C. S. BENNETT. Eng. News-Rec., 102: 599–601, April 11, 1929. Data given on effect of Miami Conservancy District flood control works on excessive runoff created by storm of moderate intensity on February 25–26, 1929. This storm provided best test of works since their completion in 1922. Studies are made of every storm which occurs.—*R. E. Thompson.*

Use of a Submarine Cutting Torch at High Bridge Viaduct. Eng. News-Rec., 102: 514–5, March 28, 1929. Brief illustrated description of use of electric

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

arc cutting torch in removing cofferdam constructed of interlocking steel sheet-piling made waterproof by pouring concrete in joints.—*R. E. Thompson.*

Contraction-Joint Treatment in the Pardee Dam. F. W. HANNA. Eng. News-Rec., 102: 457–8, March 21, 1929. Illustrated description of contraction joints in Pardee concrete dam of East Bay Municipal Utility District. Maximum height of dam is 359 feet. Up to height of 179 feet, contraction joints are spaced at 150-foot intervals; from 179 to 279 feet, a 75-foot spacing is used; and from this level to top, spacing is 37½ feet. Each joint is recessed to depth of 1 foot and width of 10 feet at intervals of 10 feet across face of joint. Copper water-stops and galvanized iron grout-stops were placed in joints. Dam will be completed early in summer of 1929 and grouting will be carried out during following winter. Contraction joints and grouting are being provided not only to prevent cracking of masonry and leakage but also to insure as much arch action as possible to increase factor of safety.—*R. E. Thompson.*

Failure of Dividing Wall in Old Coagulation Basin of Baltimore Water Filtration Plant. JAMES W. ARMSTRONG. Eng. News-Rec., 102: 597–9, April 11, 1929. On morning of March 22, coagulation basin number 2 of older of the two Baltimore plants was emptied, basin number 1, adjoining, being full at time. About 11.30 a.m., without warning, eight 32-foot sections of dividing wall between basins gave way and were pushed horizontally outward into basin number 2, liberating 8 million gallons of water, many tons of earth, broken concrete, and floor slabs being carried along. Details of construction and failure given. Basins are each 317 feet long and 232 feet wide. Division wall was 12 inches wide at top and had uniform batter of ⅜ inch per foot on each side. It was 14 feet high at upper end and 19.5 feet at lower end. Center of wall projected 2 feet below bottom of base to provide anchorage for steel reinforcement. Floor was of unreinforced concrete, 6 inches thick. Foundation was on material known locally as rotten rock, which was firm and hard when covered with concrete.—*R. E. Thompson.*

The Application of Protective Coatings on Concrete. RICHARD GRÜN. Tonind-Ztg. 52: 824–6, 1928. cf. C.A., 21: 4041. From Chem. Abst., 22: 3030, August 20, 1928. Heavy asphalt coating upon concrete made with cement low in lime gives best results with acids. Bituminous coatings are valuable against aggressive action of most salts. Concrete should be carefully made with plenty of cement, with trass admixtures, properly graded aggregates, and about 10 percent of water. Concrete should be allowed to age as much as possible and surface must be clean and dry. Greatest care should be observed in applying protective material. First coat of bitumen should be well diluted, and second and third applied without dilution, time for thorough drying being allowed after each application.—*R. E. Thompson.*

The Removal of Phenol from Ammonia Liquor with Recovery of Raw Phenol or Phenolate Lye. ERICH KOCH. Teer u. Bitumen, 26: 281–4, 1928. From Chem. Abst., 22: 3035, August 20, 1928. Description and discussion of present industrial practice. Recovery of considerable quantity of benzol retained

by ammonia liquor after extraction of phenols by benzol is necessary to economic success of process. This may be accomplished by washing with paraffin oil.—*R. E. Thompson.*

Removal of Phenol Wastes from Gas Plants. LOUIS SHNIDMAN and LINN B. BOWMAN. Gas Age-Record, 61: 626–8, 634, 1928. From Chem. Abst., 22: 3281, September 10, 1928. Summary of study of action of phenol wastes upon sanitary sewage and upon sludge digestion in Imhoff tanks. Ammonia still waste can be added to sewage in ratio of 1:2000 without ill effects on operation of Imhoff tanks. Only small quantity of phenol is destroyed in this manner. Trickling filters, or activated sludge, apparently destroy the phenols.—*R. E. Thompson.*

The Removal of Phenols from Waste Liquors of By-Product Plants and Its Economic Importance. A. WEINDEL. Glückauf, 63: 401–9; Chem. Zentr., 1927, I, 2233. From Chem. Abst., 22: 3035, August 20, 1928. Harmful effects of phenols described, with particular reference to their effect on flora and fauna of streams. Methods of removing phenols from ammonia liquors, which contain 1.5–4.5 grams per liter, are discussed. Use of waste liquors for quenching coke, treatment with gases of combustion and steam in special towers, and biological decomposition by FOWLER process improved by BACH, have almost wholly been replaced by processes in which phenols are recovered. PREISS process, i.e., neutralization of waste liquors freed from lime sludge with sulfuric acid, extraction with benzol, and precipitation with sodium hydroxide, is uneconomical. Process introduced by Emscher Genossenschaft is more advantageous. This method, which is described in detail, involves direct extraction from ammonia liquor with benzol, washing with sulfuric acid, and removal of pyridine so that pure white ammonium sulfate is produced.—*R. E. Thompson.*

The Problem of the Purification of Ammoniacal Waste Liquors. E. OTT. Monats-Bull. Schweiz. Ver. Gas-Wasserfachmännern, 7: 75–8; Chem. Zentr. 1927, I, 2496. From Chem. Abst., 22: 3035, August 20, 1928. Discussion of importance of removing phenols from ammonia waste liquors from standpoint of water pollution, with particular reference to conditions in Switzerland. BACH process perfected by Emscher Genossenschaft, in which phenols are ozidized biologically, and purification possible by this means, are described in detail—*R. E. Thompson.*

Effect of Various Salts in the Mixing Water on Compressive Strength of Mortars. F. E. GIESECKE, H. R. THOMAS and G. A. PARKINSON. Univ. of Texas Bull. 2730: Public Roads, 8: 248–9, 1928. From Chem. Abst., 22: 3031, August 20, 1928. Data given on effect of various salts. Relatively few natural waters have total solids content sufficiently high to make them unsafe for use in concrete.—*R. E. Thompson.*

Lecture Experiments on the Hydrogen-Ion Concentration Changes in the Rusting of Iron. W. R. G. ATKINS. Marine Biol. Lab. Nature, 121: 615,

1928. From Chem. Abst., 22: 3084, September 10, 1928. In rusting of iron, a trace of acid must be present. Ferrous salt is first formed, and this on oxidation to ferric salt regenerates the acid because of larger degree of hydrolysis. Experiments demonstrating course of reaction described. Bromophenol blue gives acid reaction (pH less than 3.2) in dilute solution of ferric salt. Ferrous sulfate gives purple color, indicating no greater acidity than pH 4.2. On standing, latter is oxidized, resulting in increased acidity of solution. Reaction may be made instantaneous by adding dilute hydrogen peroxide solution (pH 5.6). Action of carbon dioxide in solution may be shown with bright iron wire in distilled water containing bromthymol blue. Trace of sodium bicarbonate is first added to bring pH to 6.7. On standing, iron is attacked by carbonic acid present, and solution becomes less acid, particularly around wire. When initial solution has higher acidity rate is slower, indicating that it is the ferrous hydroxide resulting from hydrolysis which is oxidized. Reaction also proceeds slowly with slightly alkaline solutions. With phenol red an alkaline reaction (pH 8) is finally obtained, and also with xylenol blue (pH 8.4–8.6). Iron wire standing in tube of distilled water causes continuous absorption of carbon dioxide, and when acid is set free by adding hydrogen peroxide as above, resulting pH is about 4.6, showing that solution is nearly saturated with carbon dioxide.—*R. E. Thompson.*

The Detection and Colorimetric Determination of Traces of Aluminum. I. M. KOLTHOFF. J. Am. Pharm. Assoc., 17: 360–1, 1928. From Chem. Abst., 22: 3112, September 10, 1928. In weakly acid solutions, hydroxymethylanthraquinone is a very delicate indicator for aluminum, a purple color being produced. Buffer solution consisting of 10 volumes of 5N acetic acid and 9 volumes of 5N ammonium hydroxide is used. To 10 cc. of solution containing 0.02–1.0 p.p.m. aluminum, 0.25–1.0 cc. of buffer solution and 0.3 cc. of 0.1 per cent indicator in ethyl alcohol are added. After 15–30 minutes color is compared with blank and standard solution of aluminum. At 50° test is decisive in 5 minutes. Copper salts have disturbing effect but difficulty may be overcome by adding excess of sodium thiosulfate. Iron, antimony, tin and bismuth interfere but this may be overcome by addition of sodium potassium tartrate or sodium tartrate, which, however, reduces sensitivity for aluminum. —*R. E. Thompson.*

The Effect of Chlorine on the Bacteria in Water. M. DÜGGELI. Mitt. Lebensm. Hyg., 19: 126–37, 1928. From Chem. Abst., 22: 3248, September 10, 1928. Effects of amount of chlorine, temperature, time of exposure, and addition of small amounts of lactose, peptone, and algin substance were studied. Water containing flocculent suspension of organic material must be filtered before chlorination. Water treated with amounts of chlorine up to 0.5 p.p.m., showing practical absence of bacteria, may develop on standing for short time at room temperature a number of moulds exceeding original concentration of bacteria.—*R. E. Thompson.*

Embrittlement of Boiler Plate. SAMUEL W. PARR and FREDERICK G. STRAUB. Univ. of Illinois, Eng. Expt. Sta. Bull., 177: 71 pp., 1928. From

Chem. Abst., 22: 3125, September 10, 1928. Résumé of 3 years' work on embrittlement, containing information concerning failures due to this cause and data obtained from laboratory and plant tests. Embrittlement was caused by combined action of stress and chemical attack brought about by presence of sodium hydroxide in boiler. Photomicrographs showed cracks to be intercrystalline. Effect of heat treatment, steam pressure and temperature stress, hydroxyl-ion concentration, and sodium chloride on rate of embrittlement were studied. Sulfates in water in proper ratio to sodium carbonate content will prevent embrittlement. Phosphates, tannates, chromates, acetates, etc., will also inhibit attack. Methods of treatment given.—*R. E. Thompson.*

Determination of the Iodine Content of Drinking Water. HERMANN SCHRÖDER, J. F. RIETH, and S. N. BLUMSTEIN. Chem.-Ztg., 52: 440, 1928. From Chem. Abst., 22: 3245, September 10, 1928. DRAWE (C.A. 22: 1419) published method for determining iodine content of water which has brought forth vigorous independent letters of protest from above 3 scientists, all of whom point out that method is not sensitive enough to detect iodine in low concentrations which are likely to be present in drinking water.—*R. E. Thompson.*

Report of the Water-Softening and Purification Works for 1927, Columbus, Ohio. CHARLES P. HOOVER. The City Bull., Columbus, O. Ann. Rept., 1927, 27–35; cf. C.A. 22: 1816. From Chem. Abst., 22: 3246, September 10, 1928. Per capita consumption of water was 98 gallons per day. Hardness was reduced from 230 p.p.m. to 87. Cost of lime, soda-ash and chlorine per million gallons treated was $14. Carbonation effectively reduced phenolphthalein alkalinity from 33 to 7 p.p.m. Only difficulty in operating carbonation plant was due to corrosion of valve seats of compressor. Full details given in 12 tables.—*R. E. Thompson.*

Biological Purification of Water for Brewing. M. STRELL. Wochschr. Brau., 44: 607–13, 1928. From Chem. Abst., 22: 3248, September 10, 1928. Microorganisms can be removed by filtration through Berkefeld filter, or, with larger volumes, with sand filter. They can be destroyed by chlorination, ozone treatment, or electroösmosis. By latter method 50–100 liters per hour, free from bacteria and salts, can be obtained from water containing 400 grams total solids per cubic meter and having hardness of 12.4 degrees by means of current of 30 kilowatt-hours.—*R. E. Thompson.*

Spontaneous Precipitation of Salts in Rivers Receiving the Residual Liquids of the Potash Industry. EMMERLING. Chem.-Ztg., 52: 398–9, 1928. From Chem. Abst., 22: 3248, September 10, 1928. Considerable quantities of magnesium oxide are precipitated in beds of certain rivers. This precipitation is due to residual liquids of salt industry which contain very fine suspension of clay and calcium carbonate. In absence of clay, carbonate would not precipitate magnesium oxide. Humic acid also plays important rôle. Plants growing in the rivers, principally *Potamogeton pectinatus* and *Cladophora* separate an appreciable amount of calcium and magnesium oxides.—*R. E. Thompson.*

Industrial Wastes Affect Plant Water Supply. D. C. CARMICHAEL. Power Plant Engineering, **32**: 711–4, 813–5, 1928. From Chem. Abst., **22**: 3248, September 10, 1928. A study of stream polluted with wastes from iron mill. Effects on feed water for boilers and cooling water for condensers are noted. Treatment of plant water outlined. Neutralization with lime and recovery of ferrous sulfate suggested as remedy.—*R. E. Thompson.*

Water Permeability of Concrete. W. PETRY. Zement, **17**: 318–9, 1928. From Chem. Abst., **22**: 3275, September 10, 1928. Report of commission investigating concrete structures subjected to water under pressure includes following: (1) Imperviousness is in direct relation to cement content. (2) Admixtures such as stone, flour, lime, etc., do not alter above relationship. (3) Density of concrete cannot be predicted from content of mixing water without knowledge of particle size and ratio of quantities of sand and gravel. (4) Natural gravel and sand give much denser concrete than crushed materials. (5) Moist curing was better than air curing, though air-cured specimens sealed themselves quickly when exposed to water. (6) This sealing proved to be temporary, as under intermittent wet and dry treatment, air-cured concrete showed return to previous state between wettings. (7) Time of curing between 53 and 97 days had little effect. (8) When self-sealing effect is left out of account, permeability bears simple relation to water pressure. (9) Surface treatment with pitch proved successful. (10) Layers of 1:2 and 1:3 cement mortar, 2–3 centimeters thick, were tight up to 10–15 meters of water. (11) Metal sprays made water-tight concrete up to 15 atmospheres pressure.—*R. E. Thompson.*

The Treatment of Water-Gas Plant Waste. E. J. MURPHY. Gas Age-Record, **61**: 817–8, 1928. From Chem. Abst., **22**: 3281, September 10, 1928. Installation at Brooklyn Union Gas Co. plant is described. Raw effluent (waste water) from separators is treated in mixing tank with 5 pounds of lime and 4 pounds iron sulfate per 1000 gallons of effluent. Suspended matter coagulates almost immediately and is separated in Dorr clarifier. Cost is 24 cents per 1000 gallons.—*R. E. Thompson.*

Sulfate-Reducing Bacteria in California Oil Waters. RUDOLPH GAHL and BELLE ANDERSON. Centr. Bakt. Parasitenk., II Abt., **73**: 331–8, 1928. From Chem. Abst., **22**: 3286, September 10, 1928. Out of 40 wells sampled, 17 gave cultures of sulfate-reducing bacteria. In no case were positive cultures found in surface waters. All cultures were salt-tolerant and were variations of original *Sp. desulfuricans* of BEIJERINCK.—*R. E. Thompson.*

Hydrogen-Ion Concentration; Its Determination and Relation to Paper Industry. ARTHUR ST. KLEIN. Papier-Fabr., **26**: 145–51; Wochbl. Papierfabr., **59**: 140–7, 1928. From Chem. Abst., **22**: 3298, September 10, 1928. General discussion of subject and experiences in boiler plant and water purification work.—*R. E. Thompson.*

Surface Protection of Concrete Against Corrosive Waters. H. DUBIEL. Zement, 17: 70–2, 1928. From Chem. Abst., 22: 3275, September 10, 1928. General discussion of present methods.—*R. E. Thompson.*

White Water Treatment. JAS. STRACHAN. World's Paper Trade Rev., 89: 704, 770, 772, 1928; Paper Maker & Brit. Paper Trade J., 75: 339B, 1928. From Chem. Abst., 22: 3295, September 10, 1928. Discussion of requirements of white-water treatment system, two aims of which are recovery of stock and prevention of pollution. Advantages of closed white-water system, which is shown to be entirely feasible and practical, discussed.—*R. E. Thompson.*

Pipe Corrosion and Protection. W. G. HAGAN. Gas Age-Record, 61: 697–8, 1928. From Chem. Abst., 22: 3282, September 10, 1928. Discussion.—*R. E. Thompson.*

The Development of Pipe Line Construction. Apparatebau, 40: 157–9, 1928. From Chem. Abst., 22: 3320, September 20, 1928. Special flange for high pressure lines, and special form of expansion bend described.—*R. E. Thompson.*

Maintaining Efficiency of Evaporators, Cooling and Condensation Coils. S. SCHÜTZ. Wochschr. Brauw., 45: 244–8, 1928. From Chem. Abst., 22: 3319, September 20, 1928. Common theories of rusting of iron and its prevention by protective coatings discussed. Paint containing chromium has been found very effective against rusting.—*R. E. Thompson.*

Electric System of Preventing Corrosion of Boilers, Water Heaters, etc. A. GOMEZ. Brit., 281,244, November 26, 1926. From Chem. Abst., 22: 3322, September 20, 1928.—*R. E. Thompson.*

A Simple, Cheap, and Rapid Method for Measuring Hydrogen-Ion Concentration. LEOPOLD POLLAK. Gerber, 54: 99–100, 1928. From Chem. Abst., 22: 3333, September 20, 1928. "Folienkolorimeter" described. Indicator is adsorbed by membrane permeable to water. pH value of solution is estimated from color assumed by membrane after immersion for 1 minute. Apparatus is especially adapted to turbid solutions.—*R. E. Thompson.*

The Water Supply of Lourenço Marques, Portuguese East Africa. R. H. FOX. Water and Water Eng., 30: 255–62, 1928. From Chem. Abst., 22: 3472, September 20, 1928. Detailed description.—*R. E. Thompson.*

Removal of Salts from Water by Electroösmosis. KURT ILLIG. Siemens Z., 8: 349–58, 1921; cf. C.A., 21: 208. From Chem. Abst., 22: 3358. September 20, 1928. Method, employing 3-compartment electrolytic cell, has been devised for removing salts from water by differential migration of ions under influence of electric current. Ions will migrate to respective electrodes from middle compartment, producing in this section of cell water which is of as good quality as distilled water. Time required depends on Coulomb's law and current density employed. Best anodes are of magnetite, with iron, zinc, or tin

cathodes. Activity of diaphragm depends on number and size of pores and its electrical resistance. Diaphragms of different materials are required to separate anolyte and catholyte, respectively, from middle compartment. Animal and vegetable membranes are best. Battery of several cells (3 compartment each) in series is required for best results, as diaphragms do not have uniform values for solutions of all concentrations of salts. The water is siphoned from middle section of one cell to middle compartment of next as salt concentration changes. First 4 cells require 25 volts; then 3 cells at 35; 2 at 55; and 1 at 110 volts. These make efficient battery of 10 cells, from last of which the purest water is drawn. Power costs show this method to be from one-eighth to one-third of cost of other purification methods. Method can scarcely compare economically with waste steam methods, but should be very good for small scale work where only a few liters per hour are required.—*R. E. Thompson.*

A Simplified Method for Detecting Indole Formation by Bacteria. NIKOLAUS KOVÁCS. Z. Immunitäts., 55: 311–5, 1928. From Chem. Abst., 22: 3425, September 20, 1928. Solution used was p-dimethylaminobenzaldehyde 5 grams, amyl alcohol 75 cc., concentrated hydrochloric acid 25 cc. Principle of test is that when culture in bouillon is shaken with reagent indole is extracted by amyl alcohol and reacts in medium in which color is not changed by color of bouillon.—*R. E. Thompson.*

Torquay Corporation Water Works. REGINALD V. TOMS. Water and Water Eng., 30: 247–54, 1928. From Chem. Abst., 22: 3472, September 20, 1928. Detailed description of plant.—*R. E. Thompson.*

The Gersbach Indole Method for Judging the Condition of Water. W. BLUMENBERG. Centr. Bakt. Parasitenk. I. Abt., 107: 386–92, 1928. From Chem. Abst., 22: 3473, September 20, 1928. Indole production is not a consistent characteristic of the colon bacillus; hence as test for fecal contamination it may give false negatives. Other water bacteria, especially *B. Cloacae*, may produce indole and give false positives.—*R. E. Thompson.*

Further Notes on the Colorimetric Method for Field Determination of the Carbon Dioxide Tension of Natural Waters. E. B. POWERS and J. D. BOND. Ecology, 9: 364–6, 1928; cf. C.A., 22: 471. From Chem. Abst., 22: 3473, September 20, 1928. Equation is mathematically developed by means of which the carbon dioxide tension of natural water may be calculated after making 3 pH determinations.—*R. E. Thompson.*

Deconcentrating Treatment of Boiler Water. H. L. GRIFFIN. Power Plant Engineering, 32: 869–70, 1928. From Chem. Abst., 22: 3473, September 20, 1928. Continuous blow-down is made economical by utilizing heat of blow-down water to heat fresh feed water. Regulators make it impossible for blow-down water to leave deconcentrator before its temperature has reached 65°F. —*R. E. Thompson.*

Treatment of Waste Waters. T. J. LAFRENIÈRE. Can. Chem. Met., 12: 196–7, 1928. From Chem. Abst., 22: 3475, September 20, 1928. Discussion of disposal of industrial wastes and sewage, outlining general policy adopted in Province of Quebec.—*R. E. Thompson.*

A Brief Method for Chemical Examination of Irrigation Waters and Alkali Soils. P. L. HIBBARD. Soil Science, 25: 351–5, 1928. From Chem. Abst., 22: 3479, September 20, 1928. Procedure described for mineral analysis of water.—*R. E. Thompson.*

Preheated Air for Boiler Furnace. P. H. N. ULANDER. J. Inst. Fuel, 1: 187–212, 1928. From Chem. Abst., 22: 3514, September 20, 1928. Discussion of use of air preheaters for boiler furnaces, particularly in conjunction with economizers.—*R. E. Thompson.*

Measurement of Steam Flow in Works Practice. H. C. ARMSTRONG and T. NORDENSON. J. Inst., Fuel, 1: 161–86, 1928. From Chem. Abst., 22: 3514, September 20, 1928. Value of steam flow measurement as means of obtaining data on production or utilization of steam by various pieces of equipment is discussed. Flow meters and calculation of flow are also dealt with.—*R. E. Thompson.*

Operating Experiences with 1300-Pound Steam Pressure. JOHN ANDERSON. J. Inst. Fuel, 1: 131–60, 1928. From Chem. Abst., 22: 3514, September 20, 1928. Major troubles have been experienced in operation of high-pressure installation at Lakeside Station in Milwaukee, largely due to scale and corrosion, but it is felt that widespread adoption of 1300-pound steam pressure will occur in near future. Experiences are discussed in detail.—*R. E. Thompson.*

Operating Experience with High Pressure Steam and High Temperature Steam. GEO. A. ORROK. Combustion, 18: 308–10, 1928. From Chem. Abst., 22: 3514, September 20, 1928. Review of operating experience and high pressure development in past 5 years.—*R. E. Thompson.*

Determination of Carbon Monoxide in Flue Gases. K. HOFER. Glückauf, 63: 660–1; Chem. Zentr., 1927, II, 200–1. From Chem. Abst., 22: 3515, September 20, 1928. To determine carbon monoxide on the spot in flue gases, where method with cuprous chloride in Orsat apparatus is not sufficiently precise, it is recommended that 2 WILHELMI pipets with 90 and 110 cc., respectively, of ammoniacal silver nitrate solution be used and determination carried out as purely colorimetric method.—*R. E. Thompson.*

Progress in the Purification of Surface Water. H. HAUPT. Vom Wasser, Ver. deutscher Chemiker, Berlin, 2: 15, 1928. HAUPT describes modern American methods for the purification of surface waters for industrial use. Constant biological examination and treatment with copper salts is recommended for control of algae. A minute amount of copper salt remaining in the water may be harmless hygienically, but may not be so in all industrial uses.

For sedimentation it is possible to calculate the rate of fall, which depends on the weight, size, and shape of particles and on the area of floor surface, not on the depth. The best results are got by stirring sediment-rich waters with partly cleared water in a rectangular tank. It is worth while to use settling tanks first even if chemical separation and filtration are afterwards necessary. For precipitating finely divided and colloidal suspended matter the new American plants use filter alum, composed of almost equal parts of normal and basic aluminum sulphate. If there is much earthy matter, ferrous sulphate and lime are used before the alum. The process is most satisfactory when the water has pH value of 5.3–5.4. The best condition for the removal of colouring matters is pH value 4.4–4.5. The important point is thorough mixing for which special appatatus has been designed at the new American plant at Baltimore. In Germany the plants often consist only of settling tanks and filters which are not sufficient to deal with the water when the rivers are high and turbid. Variations in quality of products may cost more than installing modern plant. HAUPT gives a description of the Howard Bend Plant at St. Louis which deals with the very turbid sludgy Missouri water.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Purification of River Waters. Discussion introduced by A. SPLITTGERBER. Vom Wasser, Ver deutscher Chemiker, Berlin, 2: 170, 1928. SPLITTGERBER stated that the problem concerned the removal from river waters of the fine suspended and colloidal matter which was still present after settling and filtration. The treatment with aluminum sulphate, a further filtration at the place of use, and a longer time of filtration all meant much expense for plant or material. Experiments with chlorination were in progress. HAUPT pointed out the importance of preliminary treatment and the advantage of carrying out alum treatment in groups of waterworks rather than in single works. ORNSTEIN said that very polluted waters should be dealt with by treatment with aluminum sulphate and chlorine with subsequent clarification and filtration. BACH pointed out that methods must differ for different waters. Where space was available, long storage in large reservoirs was a cheap method of purification. Coagulation and subsequent rapid filtration, chlorination, and treatment with potassium permanganate to avoid taste were also possible methods. Biological examination of the water at different seasons was also important. The abstraction of water from a river and the necessity of returning it are factors which must be dealt with.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Progress in the Purification of Water for Laundry Purposes. K. BRAUNGARD. Vom Wasser, Ver. deutscher Chemiker, Berlin, 2: 164, 1928. The evil effects of hard water and the advantages of the permutit system of softening over the old precipitation system are described. The saving in Germany by the use of soft water is estimated at about 250 million marks yearly on the cost of fabric alone, neglecting the saving in soap. Yellowness after washing with soft water may be caused by the hydrolysis of excess soda. The use of 1 part

of soda to from 3 to 4 of soap is recommended. Yellowing may also be caused by presence of iron or manganese. Iron can be removed by aëration when it separates as an insoluble hydroxide. Manganese removal is more difficult, but the Permutit Co. use an interchange process with the use of free oxygen. The addition of softening agents to water in the washing machines is not recommended as the fabric then acts as a filter and is unavoidably damaged. Turkey red oil and soaps made from the sulphonated fatty acids from vegetable oils are not reliable methods of ensuring purity and softness. This is only possible when the hardening substances are removed before the water is used. Surface water can generally be used after coagulation of suspended colloidal matter and filtration. Ground water is already filtered by the earth but requires softening and removal of iron and manganese. In the **Discussion** the speaker also stated that the presence of copper was dangerous.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Production of Base-Exchanging Substances. A. ROSENHEIM. B. P. 279,028. J. Soc. Chem. Ind., **48**: B. 322, 1929. Artificial or natural silicates are treated at high temperatures and pressures with aqueous solutions of some inorganic compound that will supply the required base-exchanging constituent. Two or more successive treatments with different solutions may be necessary. For example, granite may be treated first at 200° and 16 atm. with hydrochloric acid, and secondly at 150° and 10 atm. with sodium silicate solution.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Katadyn; a New Method for Sterilising Water. A. THIEME. Chem. Ztg., **53**: 285, 1929. Fine silver was blown on to a rough support, e.g. porcelain, to form a surface, composed of very finely divided particles. This metal surface was found to possess both oxidising and sterilising properties. On account of this twofold action it is called Katadyn, and used as the sterilising principle in the new process. Water, containing as much as 21 million bacteria per cubic centimetre was sterilised in 48 hours by the oligodynamic action of the finely divided particles of this active metal. Also, water sterilised by this method possesses itself the power of sterilisation, owing to the presence of silver ions. The apparatus for the Katadyn process effects filtration at the same time as sterilisation. Neither substances usually present in water, nor changes in temperature seem to affect the mechanism of Katadyn, nor does the apparatus need control or inspection. It is, besides, a very cheap process, because the additions of silver required are almost negligible. Two small domestic filters are described, with diagrams. The activated water produced by this process could be put to various uses. Milk bottles could be sterilised by filling them with activated water overnight. Swimming pool water could be circulated through a Katadyn steriliser, and the activated water would destroy any fresh bacteria entering the bath. Sterilised ice, formed from this water could be used for preserving food. The editor notes that this process needs further testing, before it can be employed on a large scale.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Sterilisation of Water and other Liquids by Metal Circuits in Direct Contact with the Liquid. M. G. LAKHOVSKY. Comptes Rendus Acad. des Sci., 188: 1069, 1929. The bactericidal property of silver has been known for some time. The author considers that this action is purely physical and due to the alteration in the oscillation of the nucleus of the bacteria in contact with the metal. Plates of silver were suspended in water containing *B. coli* and the typhoid bacillus. All bacteria were destroyed after 25 hours. Some of this sterilised water was divided into three. One portion was left, another heated to 115°F., and the third filtered. *B. coli* was added to the three solutions. The unfiltered sterilised water had an immunising effect on the bacteria but in filtered portion bacteria developed normally showing that bactericidal action of the metal is physical and not chemical. The experiments were repeated with the alloy platonix. The power of the metal slowly decreases, owing to deposit of lime and organic matter from the water. It can be reactivated easily by washing with acid or base. This method of sterilisation alters the mineral composition of the water much less than boiling or addition of chemicals, and should be of great service for obtaining drinking water in the country.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

The Water Supply of Paris. An Example of Recent Waterworks Extensions. R. LOBECK. Gesundheits-Ingenieur, 52: 161, 1929. Existing water supply of Paris is obtained partly from underground and spring water at various places some distance from city and partly from the Seine. The Seine water is purified in two pumping stations at Ivry and St. Maur. During the next 25 years the Paris supply must be increased by 1.2 million cubic metres daily. There are two possible sources; surface water from the Seine and underground water from the Loire valley. The St. Maur waterworks, slightly enlarged, could be utilised to purify the extra Seine water, but the greatest water demand corresponds with the summer low water of the Seine, and it would be necessary to build pumps and weirs to store a large part of the spring high water. Also the Seine water is highly polluted and has a high temperature in summer. The proposal for using water from the valley of the Loire, despite the high cost of piping, is to be preferred, owing to the pure quality of the water throughout the year. Investigations have proved that the extra million cubic metres of water can easily be obtained from this source. The slope of the ground should make it possible to convey the water from the Loire to Paris without any pumping. The relative merits of five projects are discussed. The calculations for the size of piping and the reservoir must be made for the average yearly demand, in order to keep costs as low as possible. At times of highest demand surface water will have to be used to augment the underground supply.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Old and New Methods for the Treatment of Effluents from Beet Sugar Factories. Report of a Discussion of the Effluent Problem by the Association of Moravian Sugar Manufacturers at Brünn, March 1929. J. JASKOLSKI. Die

Duetsche Zuckerindustrie, 54: 374, 1929. The Wischau Sugar Factory treats 1,450,000 kg. of beets daily. If there is no rain, as was the case during last campaign, the factory is very short of water and a considerable proportion of the mixed fluming and washing waters and other waters, which have become acid, must be purified and re-used. Last season, the hot weather caused great difficulties owing to increased troublesome fermentation both in the factory and at effluent purification works. The washing, acid, and certain other effluents are mixed and purified together. The effluent from the condensation process is kept separate. The usual clarification with lime and "humin," did not prevent putrefaction, owing to the exceptional conditions. Chlorination of the effluents in the channel between the two clarification tanks, was then tried, wth immediate success. The first dose was 30 to 50 gm. of chlorine per cubic metre, but owing to improved conditions both in the factory and effluent system, it was found possible later to reduce it to 5 gm. per cubic metre, to discontinue the "humin" dose, and decrease the lime dose. The odours from the wash waters were reduced. Chlorination also made it possible to recirculate the effluents in the factory, without any detriment to the various processes; thus reducing the seasonal demand for fresh water and decreasing the load of pollution on the stream where the effluents are discharged. —*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Recovery of Phenols from Coke Plant Effluents. P. HOENING. Z. angew. Chem., 42: 325, 1929. Four experimental plants have been constructed in connection with four different mines in the Emscher district, in order to study a method for recovering phenols from ammonia liquors, in a suitable form for the market. The adoption of this method in Germany should increase the present phenol supply of 11,000 tons by 5,000 to 6,000 tons. Benzol is used to extract the phenols. It is mixed intimately with the liquor (the method of mixing being different in each plant) and the phenols are separated from the benzol later, either by distillation, or by mixture with an alkali to form a phenolate solution. A full destription of these two methods of separation is given. A comparison of operating results obtained at the plant attached to the Mathias Stinnes mine indicates that the alkali process is the more satisfactory. The liquor is dephenolised before it passes through the ammonia still, so as to avoid any toxic infection by benzol of the effluent, and to ensure, as far as possible, the recovery of all the benzol employed. The benzol also removes suspended tarry substances which would otherwise pass over with the ammonia vapours and contaminate the sulphate crystals. The liquor, containing 2.5 to 4.5 gms. of phenols per litre, is passed through two washers. The first is for preliminary purification and removal of tar. The liquor, heated to from 60 to 65°C., passes to the second washer, where it trickles down through a series of perforated trays and meets an upward flowing stream of benzol. In the distillation process the benzol containing phenol passes to a still which is heated with closed steam and provided with a dephlegmator. The crude phenol which collects at the bottom of the still, contains from 65 to 75 per cent phenols, benzol, tar-oils, and from 4 to 5 per cent pyridine. The benzol vapour is condensed and recirculated. Various methods are sug-

gested to recover the excess benzol in the ammonia liquor. In the alkali process of separation, two alkali-washers containing 30 to 35 percent solution of caustic soda, with stirring apparatus, take the place of the benzol still. Figures are given which show that the best conditions for phenol extraction are: (1) large quantities of benzol (30 to 50 percent), (2) a temperature between 60° and 65°C., and (3) a wash tower fitted with either RASCHIG rings or perforated trays. As much as 90 percent of the phenols in the benzol-phenol mixture are extracted by the alkali process, as against only 75 percent by the distillation process. Carbolic acid is the most valuable of phenols. It is, however, the most soluble in water and therefore the last to be extracted by the benzol. The crude phenols from the alkali process will be richer in carbolic than those from the distillation process, because a greater percentage of the phenols is extracted from the mixture. Not only are the phenols extracted by the alkali process of greater value, but the operating costs of this process are only 17.67 M. per 100 kg. of phenols as opposed to 28.07 M. by the distillation process. The extracted pyridine could also be purified, if there were sufficient market. 25,000 to 30,000 tons of phenols could be extracted yearly from the liquor produced from the 35 to 40 million tons of coal coked per annum, and this quantity would be increased if the condensate from brown coal and gas coal were also treated. The brown coal liquor contains from 10 to 15 gms. of phenols per litre.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Disposal of Ammonia Liquors. D. W. PARKES. J. Soc. Ind., 48: 81 T, 1929. Liquors from coke ovens and horizontal retorts can be treated by the activated carbon process in which 99 per cent of the phenols are removed and about 50 per cent are recovered in the form of liquid tar acids. The oxygen absorption figure is also considerably reduced, if the thiocyanate content of the liquors is low. A new continuous apparatus, consisting of a series of adsorbers, fitted with special British carbon is now used successfully. The carbon should be distilled only when saturated, to give the best recovery of phenols. The process has three stages. (1) *Acidification and settling.* Acidification is carried out with carbon dioxide, but it is best to use mineral acid with liquors containing much free ammonia because the carbon adsorbs ammonia, and on distillation it will pass over with the phenols. Mineral acid also increases the yield of liquid tar acids. (2) *Adsorption of the phenols by passage of the liquor through activated carbon.* (3) *Recovery of the tar acids and revivification of the carbon by steam distillation.* Vertical retort liquors, containing more than 0.15 per cent of pyrocatechols, can also be economically purified by the activated carbon process, if the pyrocatechols are first removed. The substances recovered are mainly pyrocatechol, homocatechol, and a few higher homologues. The recovery of catechol takes place in five stages: (1) *Pre-treatment to remove impurities* which would be precipitated by the lead salt. Sulphides and carbonates can be removed by distillation, and organic matter by precipitation with acid, or all three impurities may be removed by acidification with hydrochloric acid. If the liquor contains much free ammonia, it is best to add bleaching powder and caustic lime, to destroy the sulphides and precipitate calcium carbonate. (2) *Precipitation by lead chloride.*

To render lead chloride more soluble in liquors containing chlorides and sulphates, a concentrated solution is prepared: lead chloride 46.05 percent, sodium acetate 38.37 percent, water 14.08 percent and nitric acid (d. 1.4) 0.78 percent (all by weight). (3) *Separation and partial drying of lead pyrocatechol* by filtration which reduces the water content to between 50 and 60 percent. (4) *Decomposition of lead pyrocatechol* with concentrated hydrochloric acid, and recovery of lead chloride for recirculation. (5) *Working up crude pyrocatechol* solution by distillation under vacuum with superheated steam. This recovery of pyrocatechol might be a profitable process, if the uses of catechol were extended. In photography it can be used as a combined developer and fixer as it is not affected by hypo. Methylated catechol, guaiacol, is used in medicine. Adrenaline, vanillin, and piperonal are derived from catechol, and alizarine dye is produced on condensing it with phthalic anhydride. Recently, a patent was brought out for using dihydrozyphenols as deoxidants to render paint and varnish more weather proof. It is probable, therefore, that if the price of catechol were lowered it would find various uses.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

New Processes for the Removal of Cellulose from Industrial Waste Waters. R. SCHMIDT. Wochenbl. Papier-fabr., 59: 33, 913, 1928. Chim. et Ind., 21: 283, 1929. The new apparatus for the removal of cellulose from waste waters, (described in No. 24 of the same paper) which combines the SCHMIDT and KÖRNER-KROPP processes, is criticised by the author for two reasons. It does not take into consideration that the polluted water should be allowed to stand, and that, as the suspended matter only settles slowly, sufficient time should be allowed for it to reach the bottom of the apparatus. The author measured the rate of flow of the water at the entrance and exit in the three types of apparatus. The rates were 0.775 mm. per second in the SCHMIDT system; 0.770 and 2.30 mm. per second in the new system; and 2.43 and 1.47 mm. per second in the KÖRNER-KROPP system. From these results, it may be concluded that the new system does not effect a complete separation of suspended matter, especially in the wastes from paper factories.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Improvement of Taste of Chlorinated Drinking Water by Use of Activated Charcoal Filters. KARL IMHOFF and F. SIERP. (Translated by A. M. BUSWELL). Public Works, 60: 308–9, 1929. An experimental charcoal filter removed from 1½ to 2 percent of its weight of phenol from water having a chlorophenol taste before the taste appeared in the effluent. A 20-cubic meter charcoal filter was constructed to treat the water from a 25,000-cubic meter per day water works taking its water from a phenol-polluted source. The filter has operated very successfully and is briefly described.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Length of Filter Runs. R. J. LEVEQUE. Munic. News and Water Works, 76: 245–6, 1929. To increase the time of filter runs, the following practice

is helpful: (1) Thorough mixing of coagulants with raw water; (2) A jar sedimentation test to determine the best proportion of chemicals to use; (3) Adjustment of the pH; (4) Prevention of algae growths; and (5) Prevention of air-bound filters. Allowing a mat to settle over the sand, after a wash, while the filter is resting for a short period, will prolong a run two to five hours. Washing coagulating basins frequently proves to be more economical and assures better water.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Construction of the Wachusett-Coldbrook Water Supply Tunnel. ALFRED GARGARO and FRANK E. FAHLQUIST. Public Works, **60**: 211–217, 1929. To provide for the increased water consumption of the Metropolitan District of Boston, this tunnel, 13.2 miles long, extending from the northwesterly side of the Wachusett reservoir to the Ware River near Coldbrook is being constructed. It will carry diverted flows from the Ware River to the Wachusett reservoir and is expected to yield 30 m.g.d. The construction features, including drilling, tunnel driving, and mucking, are described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Reducing Corrosion. W. F. DAY. Munic. News and Water Works, **76**: 239–40, 1929. To ameliorate conditions at Staunton, Va., where red water and iron rust had developed, 60 pounds of sodium hydroxide per 1,200,000 gallons of water were used. Cold water pipes were cleared but hot water continued to give trouble. Stoppages in service and house pipes also appeared, due to tuberculation. A treatment plant is being constructed at a cost of $14,000 to treat the water with lime, caustic soda, or sodium silicate, in order to reduce the future corrosion of the pipe system. To remove the corrosion and stoppage already existing, 10 per cent sulfuric acid was used. Dry steam has also proved quite successful for this purpose.—*C. C. Ruchhoft (courtesy Chem. Abst.).*

Typhoid from Bathing in Polluted Water. Anon. Public Works, **60**: 192, 1929. Data from the bulletin of the Connecticut State Department of Health for March show that the typhoid rate of shore communities is not significantly higher than that of inland communities. New Haven records apparently indicate that bathing in polluted water may account for its high typhoid rate. Bathing in the polluted area has been prohibited and the entire habor has been closed for market shellfish.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Essential Facts Concerning the Failure of the St. Francis Dam. Report of Committee of Board of Direction. Proc. Am. Soc. Civ. Eng., **55**: 8, 2147–63, October, 1929. This is a report of committee composed of L. C. HILL, H. W. DENNIS and F. H. FOWLER, appointed by the American Society of Civil Engineers to compile the essential facts disclosed in the various committee reports made in connection with the failure of the St. Francis Dam in California. The dam was constructed between April, 1924, and May, 1926. It was of gravity type, arched on radius of 500 feet to up-stream face of the crest, and 700 feet long. The main dam was 205 feet high, 16 feet thick at the crest, and 176 feet thick at the base. Full reservoir capacity was reached March 5, 1928, a week

before the catastrophe. Several very large cracks had formed in the dam and along the wing-wall some months before the break. Seepage of water along the contact between dam and foundation both on the east and west sides, but particularly on the west side, was noted as soon as the reservoir was partly filled. Three weeks before the failure considerable seepage developed under the wing-wall. During the 24 hours before the dam collapsed, the seepage under the west end increased materially. There were 6 reports by committees appointed by the Board of Water and Power Commissioners of the City of Los Angeles, District Attorney of Los Angeles County, Governor of the State of California, Los Angeles City Council, Santa Clara Water Conservancy District, and Jury drawn by the Coroner of Los Angeles County. The most important features of the reports are given. All official committess agree that the dam failed because of weakness inherent in the foundations. They also agree that the concrete of the dam was of satisfactory strength.—*John R. Baylis.*

Spillway Discharge Capacity of Wilson Dam. L. G. PULS. Proc. Am. Soc. Civ. Eng., 55: 8, 2131–45, October, 1929. Author describes the current-meter discharge measurements made on spillways at Wilson Dam. Readings were taken for several gate-openings from 3 feet to full gate, with no discharge and with full discharge through adjacent spillways. When the adjacent gates were fully opened, the discharge of one 38-foot spillway under a head of 18 feet on the crest at full gate is 10,848 cubic feet per second. The 58 openings give a total spillway capacity of 629,184 cubic feet per second.—*John R. Baylis.*

Occurrence of Silicates in Natural Waters. O. W. REES. Ind. Eng. Chem. (Analytical Ed.), 1: 200, 1929. The work presented shows the advisability of reporting silica as a negative ion ($SiO^{=}_{3}$). When computing the ionic-total solids ratio, it should be placed with these ions. This system has particular advantage when reporting a boiler water analysis.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Comparison of the Dilution and Absorption Methods for the Determination of Bio-Chemical Oxygen Demand. G. E. SYMONS with A. M. BUSWELL. Ind. Eng. Chem. (Analytical Ed.), 1: 214, 1929. A modification of the SIERP method was developed giving comparable results. Anomalous results were not obtained. The method may be advantageously used for trade waste and sewage studies.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Student's Potentiometer. Leeds & Northrup Company. Bulletin 765, 1929. The L & N Student's Potentiometer has been designed for teaching the potentiometer principle and for making measurements which will emphasize the advantages of the potentiometer method. Features which adapt this instrument especially to student use are: The accuracy is high enough to command the respect of students, and to justify the use of the instrument for serious investigational work as well as for instrument calibration; it is ruggedly built and comparatively inexpensive; it is suitable for a wide variety of measurements in the educational laboratory; the circuits are simple and clear

to the students, and all accessories such as keys, switches, galvanometer, standard cell, etc., must be connected by the student, thus making him familiar with the potentiometer circuit, and, in general, the design follows that of the type K Precision Potentiometer, so that work with the Student's Potentiometer is excellent training for later work with the type K instrument. The use of the potentiometer in the standardization of electrical instruments, the measurement of temperature with thermocouples, and the measurement of electrode potentials is outlined.—*A. W. Blohm.*

Photometers. Leeds & Northrup Company. Catalog 60, 1929. The construction and uses of the Bar, Sphere and Portable types of photometers is given in this catalog.—*A. W. Blohm.*

Notes on the Kelvin Bridge. Leeds & Northrup Company. Note Book 4, 1929. "The chief purpose of this note book is to provide information that will be of assistance in the operation of a Kelvin bridge. The fundamental principles of the Kelvin bridge method of measuring low resistance are first explained, and then follows a discussion of several types of Kelvin bridge suitable for different applications of the method."—*A. W. Blohm.*

The Work of the Ohio State Department of Health Upon Water Purification and Stream Pollution Control. Committee for the Correction of Stream Pollution Ohio Manufacturers Association. Much has been accomplished by the coöperation of municipalities and industries under the direction of the Ohio State Department of Health in correcting the pollution of streams following the passage of a stream pollution law in 1925. This pamphlet presents a concise yet detailed review of this work and points out that additional laws, departments or bureaus are not needed, but rather increased funds and transportation facilities for the agency now charged with this work, the sanitary engineering division of the State Health Department. The appendix includes details of the 1925 act and five tables listing recently constructed and proposed sewage treatment plants; sewer rental ordinances; sewage treatment plants of municipalities having technical control and the various industrial waste plants in Ohio subdivided into the following classification: (*a*) By-product coke; (*b*) acid iron; (*c*) canneries; (*d*) milk and dairy; (*e*) beet sugar and (*f*) straw paper.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Water Chlorination in the Fight Against Yellow Fever. P. Bunau-Varilla. C. R. Acad. Sci., 187: 22, 1005, November 26, 1928. Tropical Diseases Bulletin, 26: 4, 308, April, 1929. A suggestion that the chlorination of tap water, by killing vegetable growth and so making the water unfavorable for the breeding of mosquitoes, will help in the suppression of yellow fever.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Thirtieth Report of the State Board of Health of the State of New Hampshire, For Fiscal Period Ending June 30, 1928. This annual report contains the results of examination of public water supplies with tabulated lists of supplies; report on industrial cross connections with table; a report on the pollution of

the Contoocook River; information relative to summer camps, tabulated, and reports on various water and sewerage problems —*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*

Typhoid Carriers in Maryland. Anon. Monthly Bulletin, Maryland State Department of Health, **4**: 2–4, June, 1928. A brief history of typhoid carriers in Maryland, from 1884 to 1928, shows a total of 84 carriers reported from which 346 cases of typhoid have occurred. The largest number of cases traced to one individual carrier was 56. Various data are given to show distribution of color, occupation, and type of carriers.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.*

Purification of Swimming Pools by Chlorine. W. HILLAND. Gesundh. Ing., **51**: 510–1, (1928); Wasser u. Abwasser **25**: 43; Chemical Abstracts, **23**: 11, 2777, June 10, 1929. The usual brownish color of swimming pool water was entirely removed by the use of Cl. Although $Ca(OCl)_2$, NaOCl, Caporit, Cl gas and chloramine were all good water disinfectants, the hypochlorites gave a troublesome and objectionable turbidity. Chloramine has 3 times the bactericidal efficiency of Cl gas and is particularly efficient in destroying organisms of the colon group. Chloramine is less odorous and is handled more readily than Cl gas.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Disinfection of Small Water Supplies for Vacationists. Anon. Alameda County Public Health News, California, **7**: 5, 9–10, May, 1929. This short article calls attention to the possibility of disinfecting drinking water with iodine. Three drops of tincture of iodine is sufficient for one quart of clear water and six drops if the water is colored, cloudy or contains sediment. Water should be allowed to stand 15 minutes. The brown color may be destroyed by adding a pinch of sodium thiosulphate which is the chemical used for "fixing" in photographic work.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Purification of Effluents from Beet Sugar Factories, With Special Reference to Fisheries. (J. Gennerich. Fischerei-Zeitung, 1926, **29**: 449). Wasser u. Abwasser. 1928, **24**: 319. Dept. of Scientific and Industrial Research. Water Pollution Research Board. Summary of Current Literature, **2**: 4, C-25, February, 1929. Experiments were undertaken to ascertain whether it is better to purify the beet-washing wastes by passing them slowly through tanks of several days capacity in relation to flow or to allow settlement for 1 or 2 hours. After letting a waste, containing 7.12 p.p.m. of oxygen in solution stand for twenty-four hours, 1.84 p.p.m. of oxygen remained, while after passing it through tanks the oxygen was reduced to 0.422 p.p.m. The beet washing waste is most dangerous when it is decomposing and fermentation has begun. After the fermentation is completed it is less harmful. Complete fermentation out in the open air takes longer in winter than in summer. Effluents from beet sugar factories must never be passed into streams, until they are completely purified and free from all putrescible organic material.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Pre-Determining the Extent of a Sewage Field in Sea Water. A. M. RAWN and H. K. PALMER. Los Angeles Sanitary Dist. Proc. Am. Soc. Civil Eng., 55: 1167–91 (1929). Chemical Abstracts, 23: 13, 3288, July 10, 1929. The probable area of a sewage field in sea water when the quantity of flow and the direction and depth of discharge below the ocean surface are given was determined. Experimental tests using Eosine Y as a coloring agency were carried on in Los Angeles Harbor. The spread of dye from the discharge nozzle was determined by actual measurement. Formulas were developed on the basis of these findings whereby the probable limits of a sewage field at any given degree of dilution may be determined.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Clarification of Industrial Waste Waters in "Neustadt" Tanks with Special Reference to the Pulp and Paper Industry. (E. Belani. Der Papierfabrikant., 1927, 25: 646.) Wasser u. Abwass., 1928, 25: 67. Dept. of Scientific and Industrial Research. Water Pollution Research Board. Summary of Current Literature, 2: 4, C-32, February, 1929. A description is given of the method of purification of the pulp and paper industry wastes in "Neustadt" tanks.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Acid Treatment for Circulating Water. Anon. Power Engineer, February, 1929, p. 47. Water and Water Eng., 31: 364, 186, April 20, 1929. Hydrochloric acid appears to be the most suitable preventive of scale-forming salts concentration in circulating water. Arguments in favour of the acid treatment are that the acid is immediately neutralised by the carbonates in the water, excess of dosage will do no appreciable harm and condenser cleaning is eliminated. As to comparative cost, acid treatment is about 14 times dearer than lime softening treatment, but there are filtration costs to be added to the latter.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Water Supply System of Nantes. (Le Service Municipal des Eaux de Nantes.) La Technique Sanitaire, December, 1928, pp. 331–4. Water and Water Eng., 31: 364, 189, April 20, 1929. The town has now a filtered water supply from the River Loire, conveyed by gravitation into sumps whence it is pumped to slow sand filters. The purification installation comprises Puech-Chabal sedimentation basins, 32 in number divided into three series, and 28 submerged open-air sand filters covering a surface of 13,000 sq. m. Filtration speed does not exceed 2–5 cu. m. per sq. m. daily and is usually 2 cu. m. Water is raised and discharged onto the beds, then raised again and conveyed to the service reservoir by two 80 mm. cast iron mains. The pumping station contains the pumps for feeding the filters and for discharging to the reservoir. —*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Drinking Water For Travelers in the Tropics. Anon. U. S. Naval Medical Bulletin, 27: 2, 424–425, April, 1929. The use of the Lyster bag, or chlorination by calcium hypochlorite is not always practical. During expeditions in Liberia and the Belgian Congo, boiling was preferred when water was turbid. Calcium hypochlorite was found unsatisfactory because of deterioration, even

when packed in amber glass ampules. Halazone tablets are found sufficiently stable for practical purposes. Dr. Shattuck believes that sedimentation by crystalline potassium or ammonium alum is a good method to employ in the treatment of muddy water. In the event that the large amounts of alum required rendered the water acid, he suggested neutralizing with sodium carbonate or calcium hydroxide. The clarified water could then be boiled or chlorinated.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Bunau-Varilla System of Water Purification. T. H. BISHOP. The Lancet, No. 5503, Vol. 216 (No. 7, Vol. 1, 1929). February 16, 1929, pp. 371–373. This article outlines the origin and development of the Bunau-Varilla system of water purification used by the French Army during the World War and notes that the installations at Rheims and other French cities have removed this system of treatment from the experimental stage to that of proved water treatment. A description of the apparatus and devices for measuring and regulating the feeding of "eau de Javelle" (a solution of NaCl and NaOCl) to the water to be treated is accompanied by a photograph of the installation at Rheims. The special features of this process by which very small amounts of chemicals are used are observed:" (1) persistence for a long period of effective, if minute, doses of available chlorine irrespective of the relative amounts of organic matter and disinfectant which may be brought into contact in a water sample: (2) the difference in vulnerability to eau de Javelle of organisms of the typhoid groups and the colon bacilli—the latter, in experiments by the Rheims workers, proving the more resistant; (3) the feeble doses employed are actually or potentially available for more than 24 hours, and during this period their destructive action continues.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Control of Public Semi-Public Water Supplies. JOHN MONGER. Illinois Medical Journal, 55: 4, 257, April, 1929. Three million of Ohio's six and a half million obtain drinking water from surface supplies. At Cincinnati, the average typhoid fever death rate for 20 years prior to filtration was 54/100,000 and for 19 years following filtration, it was 6.1. During the past five years, the average was three. Ohio is convinced that information regarding the location of safe roadside water supplies is more valuable than attempts to prohibit the use of unsafe supplies. The lessening of stream pollution, particularly by competent operation of sewage treatment plants has an important bearing on water supplies. New sewage plants have on occasion been refused approval until definite assurances were given that funds for their operation were provided. Industries are given an opportunity to solve their industrial waste problem in coöperation with the State Health Department, rather than being coerced by force. The Interstate Stream Conservation Agreement, signed by all the States on the Ohio River watershed, was instituted originally because of the discharge of phenol wastes into the river, coming sometimes chiefly from upstream states. It has worked very satisfactorily in lessening pollution reaching the Ohio River.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Water Supply at St. Catharines. Anon. Canadian Engineer, **56**: 11, 332, March 12, 1929. The quantity of water delivered to consumers during the year averaged 4,542,674 gals. per day of which 1,585,600 gals. was used by metered consumers (industrial, commercial and suburban). The flat rate consumption was approimately 115 gals. per capita per day. The number of services at the close of the year was 7,845 and the main mileage 71.02. The amount of alum employed varied from 0.45 to 1.15 grs. per gal. and averaged 0.64. The chlorine dosage was almost constant, averaging 0.21 p.p.m. B. coli removal by filtration raged from 90 to 98 percent, and by chlorination 100 percent.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Willamette River Pollution Studies. Anon. Pacific Municipalities, **43**: 4, 167, April, 1929. This is a report of studies carried on over a period of two and one-half years to determine the status of pollution. Except for two months, September and October, it was shown that the dissolved oxygen was well above the accepted minimum amount of three parts per million.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Some Problems in Industrial Waste Disposal. A. H. Wieters. Proceedings of Seventh Annual Water Works School, University of Kansas, Lawrence, pp. 125–32. The paper contains a general consideration of the principle of waste disposal and the effect of various wastes on streams. It is stated that wastes from meat packing plants may carry bacteria pathogenic for man and animals but that other wastes affect only the appearance of the stream and aquatic life. Attention is called to the fact that the point of greatest bacterial content and the most rapid putrefactive action moves downstream from the point of addition of sewage as the temperature falls. The principal factors entering into the problem are (1) Quantity of water available; (2) reaëration of the stream; (3) temperature; (4) velocity; (5) dams or other obstructions; (6) character of waste. Figures are given to show the oxgen required by various industrial wastes.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Eijkman Fermentation Test as an Aid in the Detection of Fecal Organisms in Water. Laban W. Leiter. The American Journal of Hygiene, **9**: 3, 705, May, 1929. The exhaustive study here reported was carried out by Leiter to determine: (1) "The advantage and reliability of the Eijkman fermentation test as compared with Standard Methods in an analysis of a wide variety of waters of known purity," (2) the ability of B. coli isolated from human feces and from feces of representative warm blooded animals to ferment dextrose-peptone broth at 46°C. as claimed by Eijkman, (3) the inhibition of B. coli (isolated from common cold blooded animals) by incubation at 46°C. in dextrose-peptone broth, (4) the inhibition or destruction, by the Eijkman method, of other organisms associated with B. coli in feces and water. Water samples were collected from mountain springs, artesian wells, cisterns, creeks, rivers, and reservoirs, and from Chesapeake Bay. Standard Methods were followed in examinations, and simultaneous examinations of the same samples were made by the Eijkman method, 185 water samples being examined by the latter method and 167 samples by Standard Methods. In addition, 223 cul-

tures of organisms of the colon group were isolated from samples of feces from warm blooded animals (including 143 from man) and 93 cultures were further isolated from cold blooded animals. The essential findings were as follows: (1) The Eijkman fermentation test applied to water is selective for Bacillus coli through the inhibition of other organisms. (2) Close correlation exists between fermentation of Eijkman's dextrose-peptone broth at 46°C. and the production of indol, (3) the non-utilization of sodium citrate, and (4) the non-utilization of nitrogen in uric acid. (5) The Eijkman test at 46°C. is uniformly positive for pure cultures of B. coli isolated from human feces, and (6) for like cultures isolated from warm blooded animals. (7) The test is not positive for all B. coli cultures isolated from cold blooded animals. The author states that "The Eijkman method can thus be regarded as a means of detecting contamination of a water sample by demonstrating true Bacillus coli of warm blooded animal fecal origin,"—and adds, in effect, that this method is preferable to the Standard Methods: (1) in that it is more rapid (requiring only 16 to 24 hours), (2) presence of B. coli can be confirmed in a higher percentage (92.75 percent) of positive Eijkman tests of water than of Standard Methods positive lactose tests (78.40 percent), (3) positive Eijkman tests of water yield members of the Aerogenes-cloacae group infrequently whereas Standard Methods yields them frequently, (4) a colon-like bacillus from harmless cold blooded animals (frogs) produces gas at 37°C. (Standard Methods) but shows no gas at 46°C. (Eijkman test), hence the possibility of condemning a harmless water by the former method.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Chloro-Phenol Tastes and Odors in Water Supplies of Ohio River Cities. H. W. STREETER. Public Health Reports, 44: 36, 2149–2156. September 6, 1929. Chloro-phenol tastes and odors have been most pronounced in water supplies of Ohio River cities, due to changed methods in coke by-products industry. Tar-, phenol-, cresol-, and creosote-containing residues from recovery processes find their way into municipal water supplies. The latter coincidentally require continuous chlorination to assure bacterially safe effluent, with resulting formation of chloro-phenol and allied compounds of exceptional taste-producing properties. In tabular and graphic form are shown the seasonal character of tastes in water supplies of Ohio River cities from 1924 to 1927 and the reduction in frequency through the joint efforts of Ohio River States and manufacturers. In general the periods of phenol pollution have occurred coincidentally with shortened times of river flow and with relatively low stream temperatures; conditions unfavorable for natural purification. The behavior of phenols in the Ohio River may be due to a process of natural biochemical oxidation, proceeding along definite time-function curves at rates varying closely with the temperature, being greater at higher temperatures and conversely, as shown by MOHLMAN and his associates in studies of mixtures of phenolic wastes and sewage. The origin of continuous or frequent phenol troubles in water supplies will probably be found relatively near by, while that of occasional pollution, especially coincident with high river stages and cold weather, will probably be more distant. It is important to note that control of phenol pollution of the Ohio River has been brought

under a large measure of control by means of coöperative effort on the part of the Federal and State Governments and the industries involved, rather than by coercive legislation.—*R. E. Noble.*

Experimental Studies of Natural Purification in Polluted Waters. Stream-Pollution Investigations, U. S. Public Health Service, Cincinnati, Ohio. Introductory Note. Public Health Reports, **44**: 38, 2253–2255, September 20, 1929. One major objective in the systematic investigations of stream pollution by the U. S. Public Health Service has been to acquire more extensive and exact knowledge concerning the operation of natural agencies in the process of the purification of sewage-polluted waters. To this end the Potomac, Ohio, Illinois, and Mississippi Rivers were studied intensively with special attention to (*a*) the biochemical oxygen demand, (*b*) the numbers of contained bacteria that would grow on standard culture media, and (*c*) the quality and quantity of free plankton and organisms in the water and in the bottom sediments. Biological conditions in a natural stream are highly complex, difficult to determine accurately, variable from day to day and uncontrolled. General purpose of studies to be reported has been to acquire more definite information regarding the biological forces concerned in bringing about in polluted waters (1) the oxidation of putrescible organic matter by combination with dissolved atmospheric oxygen, (2) a reduction in numbers of bacteria of such kinds as grow on the usual standard bacteriological culture media, and (3) the life cycles of plankton and bottom sediment organisms. The guiding principle has been not only to control environmental conditions, but also to simplify them to the utmost extent found compatible with reproducing the phenomena observed in natural waters. Thus in studies of oxidation of organic matter in polluted waters, observations have been made in media inoculated with simple and known biological elements, first in pure culture, then proceeding step by step to more complex combination, until finally the inoculum consisted of portions of sewage or polluted water, which presumably contained the fauna and flora of natural waters. In the course of these studies it was necessary for the authors to develop new procedures and special apparatus which in themselves are valuable contributions. **I. Apparatus and Technique for the Study of Biochemical and Other Oxidations in Liquids.** Emery J. Theriault and C. T. Butterfield. Public Health Reports, **44**: 38, 2256–2267, September 20, 1929. "Microbial respiration," bacteriologically, and "oxygen demand," chemically, refer to what is known as air oxidation occurring in bacteriological media or polluted water. Its accurate quantitative measurement in grossly polluted waters is subject to pronounced error because of the necessary dilution with aërated water and resulting reduction of food material below requirements for important plankton forms and bacteria. The authors clearly describe in detail a closed system procedure and the technique adapted to the study of air oxidations in liquid media of high food concentration. The course of deoxygenation is readily followed; the difficulties connected with the choice of a suitable dilution water are entirely avoided; it is possible to conduct a series of tests for bacteria and plankton all on the same sample; natural conditions are closely simulated; large volumes of sample may be used; the method may be used for

the study of organisms which grow indifferently, if at all, in dilute media. Provision is made for the repeated withdrawal of samples for bacteriological and other examinations and for the maintenance of aërobic conditions throughout a series of tests. A simplified technique based on the use of the WINKLER reagents has been developed for the accurate determination of oxygen in small volumes of air. The WINKLER method has been modified to permit its use in determining the dissolved oxygen content of liquids containing large amounts of organic matter. Descriptions are augmented with tables and excellent diagrammatic figures. **II. Development of a Suitable Dilute Medium.** C. T. BUTTERFIELD. Public Health Reports, 44: 44, 2647–2658. November 1, 1929. This paper represents a contribution to our scientific knowledge and enlightens us in regard to certain factors affecting biological growth and metabolism in culture media. The author's summary is as follows: "Dextrose and peptone or dextrose and ammonium sulphate, in equal proportions, properly diluted, provide a medium which produces satisfactory growth of many bacteria. When oxygen demand determinations are to be made by the excess oxygen dilution method in such a medium it is necessary, in order to maintain aërobic conditions, to dilute the dextrose and peptone until not over 5.0 milligrams of each are present per liter. Distilled water, when used for such dilution, was found to be quite unsatisfactory. Distilled water, containing 2.5 grams of phosphate salts per liter, adjusted to pH of approximately 7.2, has been found to be a satisfactory dilution water. When thus prepared, the dilute medium sustains vigorous growth without excessive lag. The artificial mixture, or 'synthetic sewage,' described here, can be exactly reproduced and has proved of value in the study of some of the fundamental relationships existing between the bacteria and the plankton in the processes of natural purification. This mixture, while not ideal, does simulate the organic growth-supporting characteristics of ordinary sewage to a remarkable degree, for, in addition to an adequate support of bacterial life, it possesses the following characteristics, which will be covered in detail in subsequent papers: (1) If previously aërated and maintained under sterile conditions, the synthetic sewage will not use up oxygen, even in traces. (2) It will not become alkaline when sterilized by heat, or acid during incubation, if the amount of dextrose present does not greatly exceed 100 milligrams per liter. (3) It will support plankton life in the presence of bacteria and will support the plankton, *Colpidium*, in the absence of bacteria if the concentrations of dextrose and peptone are increased sufficiently to provide for the food requirements of the larger organism. (4) Under the action of various bacteria and plankton the processes of biological oxidation in this medium are qualitatively the same as those observed in polluted water and sewage. The influence of certain factors —concentration of mineral salts, pH of medium, and nature and concentration of food materials—is shown to be of marked significance for growth of bacteria in dilute media."—*R. E. Noble.*

ABSTRACTS SUB-COMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

Corrosion and Boiler Feed Water. D. G. McNair. Power Engr. (Lond.), 24: 282, September, 1929, pp. 346–348, 6 figs. Discussion of modern developments leading toward elimination of corrosion in boilers and feed systems; air in feedwater, closed-feed system; installation of de-aërators in existing feedwater systems.

Formation of Incrustation and Internal Treatment of Boilers by Chemical or Physical Means (La formation des incrustations et le traitement interne des chaudières par les moyens chimiques et physiques). J. Guth and V. Kammerer. Associations françaises de Propriétaires d'Appareils à Vapeur—Bul. (Mulhouse), 36: April, 1929, pp. 65–95, 3 figs. Analysis of scale formation and treatment with various chemicals; description of substances which act upon scale through their physical properties.

Heat Conductivity of Boiler Scale (Die Waermeleitfaehigkeit von Kesselstein). A. C. Eberle. Archiv fuer Waermewirtschaft (Berlin), 10: 10, October, 1929, pp. 334–336, 7 figs. Results of research carried out in past few years show that heat-conductivity coefficient of boiler scale depends to great extent on its porosity, and this is influenced to marked degree by composition of scale; porosity of samples studied fluctuated between 6 and 80 percent and conductivity coefficient varied accordingly between 0.1 and 2.

Outline of Fiscal Year 1928/29 of Central Federation of Prussian Boiler Inspection Societies (Uebersicht ueber das Geschaeftsjahr 1928/29 des Zentralverbandos der Preussischen Dampfkessel-Ueberwachungs-Vereine). K. Vigener. Waerme (Berlin), 52: 40, October 5, 1929, pp. 765–770. Review of activities; inspection of motor vehicles and elevators; inspection of boiler construction; work of special committees; courses for boiler firemen; research work; economizers, etc.

Prevention of Boiler Corrosion by Means of Alkali Admixtures (Ueber die Verhuetung von Kesselkorrosionen durch Alkalizusatz). A. Splittgerber. Chemische Farbrik (Berlin), 21: May 22, 1929, pp. 253–256. Method is detailed.

Recent Instances of Embrittlement in Steam Boilers. F. G. Straub. Am. Soc. Mech. Engrs.—Advance Paper for meeting, December 2 to 6, 1929, 43: 2 pp., 2 figs. Cause of recent boiler explosion at Crossett, Ark., is described, failure being attributed to embrittlement produced as result of using soda-ash treatment on water too low in sulphate content; other instances of cracking of seams in steam boilers are also described; emphasis is placed upon regular inspection of leaky seams in steam boilers, particularly when boiler water does not meet A. S. M. E. recommendation.

Unsuspected Causes of Boiler Corrosion. E. INGRAM. Mech. World (Manchester), **86**: 2226, August 30, 1929, p. 191, 2 figs. Several instances of internal and external corrosion in Lancashire boilers are described with discussion of factors causing corrosion; presence of certain impurities in fuel caused external corrosion; serious damage done by pickling water from vats used for cleaning wares.

Boiler Priming (Das Mitreissen von Wasser aus dem Dampfkessel). C. EBERLE. Archiv fuer Waermewirtschaft (Berlin), **10**: 10, October, 1929, pp. 329–333, 14 figs. Boiler priming is not alone due to steaming surface, but to great degree to content of steaming zone; of special influence is manner of conducting steam into steaming zone; results of tests.

Caustic Cracking in Boiler Drums. S. African Engr. (Johannesburg), **21**: 35, July, 1929, pp. 29–31. South African example; discussion of theory in connection with English accident; case for welded drums; evidence obtained by American investigators, particularly by PARR and STRAUB, and to some extent confirmed by work at National Physical Laboratory, definitely shows that inter-crystalline cracking is produced when caustic soda solutions of sufficient concentration act upon boiler plate steel which is at same time exposed to heavy mechanical stress.

Why It Does Not Pay to Return Boiler Blowoff to the Feed-Water Softener. J. D. YODER. Power, **70**: 12, September 17, 1929, pp. 442–443. Question has often been raised as to practicability of recovering heat in blowoff by continuously discharging latter into sedimentation tank of feed-water softener; idea has been put into practice in Europe with fair results; discussion of boiler water analysis.

Boiler Failures (Untersuchung von Kesselschaeden). Zeit. des Bayerischen Revisions-Vereins (Munich), **33**: 15, 16, and 17, August 15, 31 and September 15, 1929, pp. 213–216, 229–233 and 244–246, 25 figs. August 15: Investigation of cracks in longitudinal seam of a Lancashire boiler and hair cracks in girth seam. August 31: Rivethole cracks in manhole-cover seams; and in longitudinal seams of lower front drum of two boilers. September 15: Review of work of A. POMP and R. BARDENHEUER in Mitteilungen des Kaiser-Wilhelm-Institut fuer Eisenforschung, 1929, p. 185, previously indexed.

Cracking of Boiler Plates. A. POMP and P. BARDENHEUER. Metallurgist (Supp. to Engineer, Lond.), September 27, 1929, pp. 131–132, 1 fig. Extensive application is made of FRY'S reagent to reveal areas in which local plastic straining of steel has occurred, and which therefore has reduced ductility and increased solubility in corrosive media; three cases of cracking of boiler plates in service are discussed. Review of paper, previously indexed from Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf, No. 128, 1929.

Diphenyl. Indus. Power, November, 1929, pp. 41–42, 146, and 148, 2 figs. New substitute for water in heat engineering; yellowish crystalline substance at temperatures below its boiling point, and smelling much like moth balls; threatens to displace water wherever more rapid heat transferring is necessary; has no corrosive action on any material; it will burn at high temperatures, presumably around 1800 deg. Fahr.; not to be confused with diphenyl oxide, which is not so stable, and has not proven satisfactory because of tendency to carbonize in tubes; preliminary table of values for diphenyl.

Occurrence of Silica in Natural Waters. O. W. REES. Indus. and Eng. Chem., Analytical Edition, 1: 4, October 15, 1929, pp. 200–201. Method of feedwater analysis is described and results given by which silica is determined colorimetrically by use of ammonium molybdate reagent which was suggested first by WINKLER and later modified by NEAVE.

The Effect of Rating on Boiler Water Samples. J. N. EVANS. Power, 70: 14, October 1, 1929, pp. 520–521, 2 figs. Tests here reported show how concentration of solids in boiler water samples varied with boiler rating, location of sampling point, and method of feed.

Additional Water in Power Plants (L'eau d'appoint dans les centrales). H. SAUVAGE. Revue Universelle des Mines (Liège), 72: 2, July 15, 1929, pp. 33–42, 7 figs. Water losses from safety valves, evaporation, leakage, etc. in power plants run from 3 to 8 percent according to condition and operation methods used in plant; means and methods for avoiding losses by proper treatment of feedwater and application of distillers and degasifying equipment are discussed.

Conversion of Sodium Carbonate to Caustic Soda Within Steam Boilers. C. E. JOOS. Power, 70: 20, November 12, 1929, pp. 762–764, 2 figs. Investigation indicates that much of sodium carbonate in boiler water is quickly changed to caustic soda; in certain cases presence of sugar or other organic compounds may make ordinary indicators unreliable; curves giving test results; survey to determine effect of conditions on conversion of carbonate to caustic.

Deconcentration of Feed-Water Avoids Many Ills of Boiler Operation. E. W. SCARRITT. Nat. Petroleum News, 21: 44, October 30, 1929, pp. 107–108, 110 and 112, 4 figs. Discussion of control of chemical reaction within boiler, to change soluble salts to insoluble form; source of means for providing necessary chemicals to maintain proper balance within boiler is of minor importance, provided those reagents are suitable for water and for steaming conditions under which evaporation is taking place.

Feed Water De-Aërator. Engineering (Lond.), 128: 3320, August 30, 1929, p. 275, 4 figs. Deaërator described is entirely self-contained; water from hot well enters at top through float-controlled throttle valve; air driven off is extracted by steam jet; float gear is practically friction free.

Feedwater Treatment in American Boiler Plants (Speisewasserpflege in amerikanischen Kesselanlagen). HAUPT. Waerme (Berlin), **52**: 38, 39, and 40, September 21 and 28, and October 5, 1929, pp. 733–737, 756–758 and 773–775, 2 figs. Impressions gained on author's study trip to American Plants; popular American mixture (sulphate-carbonate) of PARR has been lately superseded by tri-sodium phosphate addition; cause of foaming and spluttering; experiences are recapitulated under 13 heads.

Feed Water Treatment of Special Importance at High Rates of Evaporation. A. R. MUMFORD. Combustion, **1**: 3, September, 1929, pp. 43–46, 3 figs. Problem of scale on boiler tubes has been greatly increased due to modern boiler design; method of solving problem is not mechanical cleaning, but chemical treatment of feedwater; diagram illustrating effect of scale on temperature gradient through boiler tube; high-pressure chemical water treating system.

Modern Feedwater Treatment (Neuzeitliche Speisewaser-aufbereitung). K. HOFER. Glueckauf (Essen), **65**: 31, August 3, 1929, pp. 1067–1071, 2 figs. Prevention of corrosion and scale formation curves, showing required carbonate concentration; prevention of brittleness in riveted boiler through cold stretching and loading over stretch limit; gas controls and density of boiler water are discussed.

Operation and Control of Boiler-Feedwater Purification Systems. S. T. POWELL. Mech. Eng., **51**: 12, December, 1929, pp. 935–940, 6 figs. Routine tests of value in control of boiler feedwater and concentrated boiler waters; cost of laboratory control and its relative value; method of analysis applicable to feedwater; test for total alkalinity; for carbonate, bicarbonate, and hydrate alkalinity; for chlorides; and for dissolved oxygen.

Plans for Chemical Purification of Feedwater along State Railroad Lines. (Impianti de Depurazione Chimica dell'Acqua per L'Alimentazione delle Locomotive sulla Rete delle Ferrovie dello Stato.) A. MICHELUCCI. Rivista Tecnica delle Ferrovie Italiane (Rome), **36**: 1, July 15, 1929, pp. 1–25, 21 figs. Descriptive notes on number of small plants for treatment of feedwater with lime and soda, installed between 1913 and 1928; organization of feedwater-treatment service, with special reference to construction and maintenance practice; data proving economy of feedwater treatment, also data on operation costs.

Purification of Boiler Feed Water. Water and Water Eng. (London), **31**: no. 370, October 21, 1929, pp. 475–477, 1 fig. Chemical analysis of water used at Hams Hall generating station of Birmingham Corporation Electricity Works; details of water-treatment plant having capacity of 288,000 gallons per day, including lime-soda plant, filter, and three Permutit pressure softeners, each 9 feet in diameter.

Recent Developments in the Purification and Treatment of Feedwater. C. L. HUBBARD. Textile World, **76**: 10, September 7, 1929, pp. 65–69, 14 figs.

Consideration of such problems as prevention of scale, elimination of active corrosion and control of priming or foaming of water within boiler; methods used for correcting unsuitable feedwater; use of boiler compounds and evaporators; various types of evaporators; electrolytic treatment; and steam purification.

Sulphate Protection and the Attack of Salt Solutions on Boiler Plate (Ursachen des Sulfatschutzes beim Angriff von Salzloesungen auf Kesselblech). E. BERL and A. VAN TAACK. Archiv. fuer Waermewirtschaft (Berlin), 10: 10, October, 1929, pp. 337–339, 4 figs. Results of tests are given; effect of soda brine; protective action of sodium sulphate; behavior of other salts; causes of attack and protective media; pretreatment with sodium sulphate; influence of sodium bicarbonate; effect of magnesium-chloride solutions containing sulphate; influence of sulphate and chloride additions on actual acidity of hydrochloric acid.

Zeolite Water-Treating System of the Beacon Street Heating Plant. J. H. WALKER and L. F. COLLINS. Indus. and Eng. Chem., 21: 11, November, 1929, pp. 1020–1024, 4 figs. Beacon Street plant is newest of several district heating plants operated by Detroit Edison Co.; factors involved in choice of zeolite softening system followed by partial neutralization with acid are outlined; article describes complete feedwater-treatment system, gives operating experiences and results of three seasons, and presents cost data for full year of service.

Hydrogen Ion Concentration of Solutions (La Concentrations des Solutions en Ions d'Hydrogène). E. LEMAIRE. Génie Civil (Paris), 95: 11, September 14, 1929, pp. 247–250. General discussion of electrolytic dissociation and its determination; hydrolysis. (*To be continued.*)

Water-Heating In Trains. Modern Transport (London), 22: 552, October 12, 1929, p. 3, 2 figs. L. N. E. R. adopts new methods on locomotives and sleeping cars; improvement on old system; delivering to boiler; lubrication; supply of current.

Power Station Chemistry. Nat. Elec. Light Assn.—Serial Report, August, 1929, 40 pp., 21 figs. Graphic method of controlling treatment in lime-soda system; laboratory study of turbine oil, using FUNK sludging machine; approved test methods for judging quality of turbine oils; desirability of making tests for hydrogen-ion concentration in water supplies; statements for plant use; graphical estimation of various alkalinities in water and plant control test for estimating phosphates in boiler water; manufacturer's statement on equipment for determination of hydrogen-ion concentration and direct reading of conductance of water.

Stabilized Starch Indicator. M. S. NICHOLS Indus. and Eng. Chem., Analytical Edition, 1: 4, October 15, 1929, pp. 215–216. Procedure is explained for preparation of commercial grade of potato starch, and starch indicator reagent.

Determination of the Hardness of Water by Means of Soap Solution (Zur Haertebestimmung im Wasser mittels Seifenloesung). G. BRUHNS. Chemiker-Zeitung (Koethen), **53**: 48, June 15, 1929, pp. 460–470. Discussion of method of BOUTRON and BOUDET.

Industrial Water Treatment. G. CAWLEY. Power, **70**: 17 and 19, October 22, and November 5, 1929, pp. 642–645, and 716–720, 8 figs. October 22: Treatment of water for potable purposes, boiler feed and manufacturing, may be divided into three general operations; removal of suspended and colloidal solids; softening; and sterilization; operations are explained in detail; water softening; illustrations of cold and hot-process softeners. November 5: Author explains underlying principles of zeolite softening and gives practical pointers on selection and operation of zeolite systems; illustrations of typical zeolite softener, arranged for downward softening, rinsing, and reconditioning; illustration showing typical combination plants.

Frequency and Arcing in Electrolysis of Water. G. W. VINAL. Am. Electrochem. Soc., Preprints and Discussions, **23**: for meeting May 27–30, 1929, 3 pp. Discussion of paper previously indexed from Am. Electrochem. Soc., Advance Paper for meeting May 27–29, 1929.

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Boiler-Feed Water Should Be Free From Oxygen. Power Plant Eng., 33: 566–8 (1929). Chemical Abstracts, **23**: 15, 3764, August 10, 1929. Description of the newly modified WINKLER iodometric method.

Preventing Scale Deposition in Water Preheaters. ALSBERG, JULIUS (to Superheater Co.). U. S. 1,717,905, June 18. Chemical Abstracts, **23**: 16, page 4004, August 20, 1929. The cold feed water is treated with colloidal chestnut extract.

Vacuum-Control Means for Boiler-Feed Deaërators. EIFERT, MARTIN, Ger. 476–320, May 11, 1926. Chemical Abstracts, **23**: 15, 3766, August 10, 1929.

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The Measurement of the Discharge of the Nile Through the Sluices of the Aswan Dam. Final Conclusions and Tables of Results. H. E. HURST and D. A. F. WATT. Cairo, Egypt: Publications Office, Government Press. Boards, cloth back: 7 x 10 in.; pp. 44 (mostly tables). 10 piasters (50¢) in Egypt. Reviewed in Eng. News-Rec., **102**: 109. January 17, 1929.—*R. E. Thompson.*

Permeazioni d'Acqua e Loro Effetti nei Muri di Ritenuta. OSCAR HOFFMAN. Milan, Italy: Ulrico Hoepli. Paper; 6 x 9 in.; pp. 125. 15 lire. Reviewed in Eng. News-Rec., **102**: 319, February 21, 1929.—*R. E. Thompson.*

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